DRAFT UPPER JEFFERSON RIVER TRIBUTARY SEDIMENT TMDLS AND FRAMEWORK WATER QUALITY IMPROVEMENT PLAN

April 28, 2009

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EXECUTIVE SUMMARY

This document presents a Total Maximum Daily Load (TMDL) and framework water quality improvement plan for six impaired tributaries to the Upper Jefferson River near Whitehall, Montana, including Big Pipestone, Little Pipestone, Cherry, Fish, Hells Canyon, and Whitetail creeks. The plan was developed by the Montana Department of Environmental Quality (DEQ).

The Montana Water Quality Act requires DEQ to develop TMDLs for streams and lakes that do not meet, or are not expected to meet, Montana water quality standards. TMDLs are the maximum amount of a pollutant a water body can receive and still meet water quality standards, or the level of reduction in pollutant loading that is needed to meet water quality standards. The goal of TMDLs is to eventually attain and maintain water quality standards in all of Montana's streams and lakes, and to improve water quality to levels that support all state-designated beneficial water uses.

The Upper Jefferson River TMDL Planning Area (TPA) is located in Madison, Silverbow, and Jefferson counties and includes the Jefferson River and its tributaries from Twin Bridges to the Boulder River confluence near Whitehall. The tributaries originate in the Tobacco Root Mountains, located in the southern portion of the watershed, and the Highland Mountains to the north. The watershed drainage area encompasses about 469,994 acres, with land ownership consisting of federal, state, and private lands.

The state of Montana has developed water quality standards per Clean Water Act direction. DEQ has performed assessments determining that a number of tributaries do not meet these standards. The scope of the TMDLs in this document address sediment related problems. The DEQ recognizes there are other pollutant listings for this TPA; however, this document only addresses sediment.

Sediment was identified as a cause of impairment of aquatic life and coldwater fisheries in Big Pipestone, Little Pipestone, Cherry, Fish, Fitz, Halfway, Hells Canyon, and Whitetail creeks. Sediment impacted beneficial water uses in these streams by altering aquatic insect communities, reducing fish spawning success, and increasing turbidity. Water quality restoration goals for sediment in these stream segments were established on the basis of fine sediment levels in trout spawning areas and the stability of streambanks. DEQ believes that once these water quality goals are met, all water uses currently impacted by sediment will be restored.

Sediment loads were quantified for natural background conditions and for the following sources: bank erosion, hillslope erosion, and unpaved roads. The most significant sources included streambank and upland erosion as influenced by agricultural activities as well as reduced sediment trapping efficiency of the vegetated riparian buffer. The Upper Jefferson Watershed sediment TMDLs indicate that reductions in sediment loads ranging from 24% to 55% will result in meeting the water quality restoration goals.

Recommended strategies for achieving the pollutant reduction goals of the Upper Jefferson River Watershed TMDLs are also presented in this plan. They include best management practices (BMPs) for building and maintaining roads, timber harvesting, and suburban development as

well as expanding riparian buffer areas and using other land, soil, and water conservation practices that improve the condition of stream channels and associated riparian vegetation.

Implementation of most measures described in this plan will be based on voluntary cooperation by watershed stakeholders, and proposed actions will not conflict with water rights or private property rights. Flexible adaptive management approaches may become necessary as more knowledge is gained through implementation and future monitoring. The plan includes an effectiveness monitoring strategy designed to track future progress toward meeting TMDL objectives and goals, and to help refine the plan during its implementation.

SECTION 1.0
INTRODUCTION

1.1 Background

This document, *The Upper Jefferson River TMDLs and Framework Watershed Water Quality Improvement Plan*, describes the Montana Department of Environmental Quality's (DEQ) present understanding of sediment related water quality problems in tributary streams of the Upper Jefferson River TPA **(Figures 1 & 2 in Appendix A)** and presents a general framework for resolving them. Guidance for completing the plan is contained in the Montana Water Quality Act and the federal Clean Water Act.

In 1972 Congress passed the Water Pollution Control Act, more commonly known as the Clean Water Act. Its goal is to "restore and maintain the chemical, physical, and biological integrity of the Nation's waters." The Clean Water Act requires each state to set water quality standards to protect designated beneficial water uses and to monitor the attainment of those uses. Fish and aquatic life, wildlife, recreation, agriculture, industrial, and drinking water are all types of beneficial uses. Streams and lakes (also referred to as water bodies) that do not meet the established standards are called "impaired waters." These waters are identified on the 303(d) list, named after Section 303(d) of the Clean Water Act, which mandates the monitoring, assessment, and listing of water quality limited water bodies. The 303(d) list is contained within a biennial integrated water quality report. (See **Table 1-1** for a list of waters identified on the 2006 303(d) List as having impairments in the Upper Jefferson River TPA, their impaired uses and probable impairment causes.)

Both Montana state law (Section 75-5-703 of the Montana Water Quality Act) and section 303(d) of the federal Clean Water Act require the development of total maximum daily loads (TMDLs) for impaired waters where a measureable pollutant (e.g., sediment, nutrients, metals, or temperature) is the cause of the impairment. A TMDL is a loading capacity and refers to the maximum amount of a pollutant a stream or lake can receive and still meet water quality standards.

The development of TMDLs and water quality improvement strategies in Montana includes several steps that must be completed for each impaired water body and for each contributing pollutant (or "pollutant/water body combination"). These steps include:

- Characterizing the existing water body conditions and comparing these conditions to water quality standards. Measurable targets are defined as numeric values and set to help evaluate the stream's condition in relation to the standards.
- Quantifying the magnitude of pollutant contribution from sources.
- Establishing allowable loading limits (or total maximum daily loads) for each pollutant
- Comparing the current pollutant load to the loading capacity (or maximum loading limit/TMDL) of the particular water body.
- Determining the allowable loads or the necessary load reduction for each source (called "pollutant allocations").

In Montana restoration strategies and recommendations are also incorporated to help facilitate TMDL implementation.

In some cases the TMDLs may not be capable of fully restoring the designated beneficial uses without the addition of other restoration measures. For example, impairment causes such as streamflow alterations or dewatering, habitat degradation, and streambank or stream channel alterations may prevent a water body from fully attaining its beneficial uses even after TMDLs have been implemented. These are referred to as "pollution" problems, as opposed to impairments caused by any type of discrete "pollutant," such as sediment or metals. TMDLs, *per se*, are not intended to address water use support problems that are not directly associated with specific pollutants. However, many water quality restoration plans (**Section 6.1**) describe strategies that consider and address habitat, streamflow, and other conditions that may impair beneficial uses, in addition to problems caused by more conventional water pollutants. The desired goal of any well designed water quality improvement strategy is to enable restoration of impaired waters such that they support all designated beneficial uses and achieve and maintain full water quality standards by using comprehensive restoration approaches.

1.2 303(d) List Summary and TMDLs Written

As per federal court order, by 2012 DEQ must address all pollutant/water body combinations appearing on the 2006 303(d) List and which were also identified on the 1996 303(d) List. Eight tributary stream segments on the 2006 303(d) List were listed as impaired in the Upper Jefferson TPA. Water bodies can become impaired from pollution (e.g., flow alterations and habitat degradation) and from pollutants (e.g., nutrients, sediment, and metals). However, because only pollutants are associated with a load, the EPA restricts TMDL development to pollutants. Pollution is commonly—but not always—associated with a pollutant, and a TMDL may be written (but is not required) for a water body that is only on the 303(d) list for pollution. Based on the 2006 303(d) List and a review of existing data for tributary streams of the Upper Jefferson TPA, 6 TMDLs were written for sediment within 8 water body segments, all of which were listed for pollution (**Table 1-1**).

The causes and sources of sediment related water quality impairments within tributary streams of the Upper Jefferson TPA vary from stream to stream. Listings include a mix of pollutant-related impairment from sediment and pollution-related impairment from substrate alterations, alterations in stream-side or littoral vegetative cover, and low-flow alterations. The scope of the TMDLs in this document address sediment related problems. DEQ recognizes there are other pollutant listings for this TPA; however, this document addresses only sediment. Pollutant-related listings other than sediment will be addressed within a timeframe identified in Montana's law (MCA 75-5-703). A review of the relevant existing data will be provided for stream segments on the 2006 303(d) List in **Sections 5.4.2**.

Table 1-1. 2006 303(d) Listed Water Bodies, Impairment Causes, and Impaired Beneficial Uses in the Upper Jefferson River TPA.

Water body & Location Description	Water Body ID	Impairment Cause	Pollutant Category	Impaired Uses
BIG PIPESTONE CREEK, headwaters to mouth (Jefferson River)	MT41G002_010	Siltation, Sedimentation	**Sediment***	Aquatic Life, Cold Water Fishery
BIG PIPESTONE CREEK, headwaters to mouth (Jefferson River)	MT41G002_010	Suspended Solids	**Sediment***	Aquatic Life, Cold Water Fishery, Industrial
BIG PIPESTONE CREEK, headwaters to mouth (Jefferson River)	MT41G002_010	Habitat Alterations	Not a Pollutant	Aquatic Life, Cold Water Fishery
BIG PIPESTONE CREEK, headwaters to mouth (Jefferson River)	MT41G002_010	Thermal Alterations	Temperature	Aquatic Life, Cold Water Fishery
BIG PIPESTONE CREEK, headwaters to mouth (Jefferson River)	MT41G002_010	Phosphorus (Total), Nitrogen (Total)	Nutrients	Aquatic Life, Cold Water Fishery, Primary Contact Recreation
CHERRY CREEK, headwaters to mouth (Jefferson River)	MT41G002_110	Siltation, Sedimentation	**Sediment***	Aquatic Life, Cold Water Fishery
CHERRY CREEK, headwaters to mouth (Jefferson River)	MT41G002_110	Low flow alterations	Not a Pollutant	Aquatic Life Cold Water Fishery Primary Contact Recreation
CHERRY CREEK, headwaters to mouth (Jefferson River)	MT41G002_110	Zinc	Metals	Aquatic Life Cold Water Fishery
CHERRY CREEK, headwaters to mouth (Jefferson River)	MT41G002_110	Alteration in stream-side or littoral vegetative covers	Not a Pollutant	Aquatic Life Cold Water Fishery
FISH CREEK, headwaters to mouth (Jefferson River)	MT41G002_100	Alteration in stream-side or littoral vegetative covers	Not a Pollutant	Aquatic Life Cold Water Fishery
FISH CREEK, headwaters to mouth (Jefferson River)	MT41G002_100	Siltation, Sedimentation	**Sediment***	Aquatic Life, Cold Water Fishery
FISH CREEK, headwaters to mouth (Jefferson River)	MT41G002_100	Low flow alterations	Not a Pollutant	Aquatic Life Cold Water Fishery Primary Contact Recreation
FITZ CREEK, headwaters to mouth (Little Whitetail Creek)	MT41G002_160	Alteration in stream-side or littoral vegetative covers	Not a Pollutant	Aquatic Life Cold Water Fishery
FITZ CREEK, headwaters to mouth (Little Whitetail Creek)	MT41G002_160	Phosphorus (Total)	Nutrients	Aquatic Life, Cold Water Fishery, Primary Contact Recreation

Table 1-1. 2006 303(d) Listed Water Bodies, Impairment Causes, and Impaired Beneficial Uses in the Upper Jefferson River TPA.

Water body & Location Description	Water Body ID	Impairment Cause	Pollutant Category	Impaired Uses
FITZ CREEK, headwaters to mouth (Little Whitetail Creek)	MT41G002_160	Siltation, Sedimentation	**Sediment***	Aquatic Life, Cold Water Fishery
HALFWAY CREEK, headwaters to mouth (Big Pipestone Creek	MT41G002_020	Alteration in stream-side or littoral vegetative covers	Not a Pollutant	Aquatic Life Cold Water Fishery
HALFWAY CREEK, headwaters to mouth (Big Pipestone Creek	MT41G002_020	Siltation, Sedimentation	**Sediment***	Aquatic Life, Cold Water Fishery
HELLS CANYON CREEK, headwaters to mouth (Jefferson River)	MT41G002_030	Low flow alterations	Not a Pollutant	Aquatic Life Cold Water Fishery Primary Contact Recreation
HELLS CANYON CREEK, headwaters to mouth (Jefferson River)	MT41G002_030	Physical substrate habitat alterations	Not a Pollutant	Aquatic Life Cold Water Fishery
HELLS CANYON CREEK, headwaters to mouth (Jefferson River)	MT41G002_030	Siltation, Sedimentation	**Sediment***	Aquatic Life, Cold Water Fishery
LITTLE PIPESTONE CREEK, headwaters to mouth (Big Pipestone Creek)	MT41G002_040	Phosphorus (Total), Nitrogen (Total)	Nutrients	Aquatic Life, Cold Water Fishery, Primary Contact Recreation
LITTLE PIPESTONE CREEK, headwaters to mouth (Big Pipestone Creek)	MT41G002_040	Alteration in stream-side or littoral vegetative covers	Not a Pollutant	Aquatic Life Cold Water Fishery
LITTLE PIPESTONE CREEK, headwaters to mouth (Big Pipestone Creek)	MT41G002_040	Siltation, Sedimentation	**Sediment***	Aquatic Life, Cold Water Fishery
WHITETAIL CREEK, headwaters to mouth (Jefferson river)	MT41G002_140	Alteration in stream-side or littoral vegetative covers	Not a Pollutant	Aquatic Life Cold Water Fishery
WHITETAIL CREEK, headwaters to mouth (Jefferson river)	MT41G002_140	Aluminum, Copper, Silver, Lead	Metals	Aquatic Life Cold Water Fishery
WHITETAIL CREEK, headwaters to mouth (Jefferson river)	MT41G002_140	Ammonia, Nitrate/Nitrite, Phosphorus, Total Kjehldahl Nitrogen, Chlorophyll-a	Nutrients	Aquatic Life, Cold Water Fishery, Primary Contact Recreation
WHITETAIL CREEK, headwaters to mouth (Jefferson river)	MT41G002_140	Low flow alterations	Not a Pollutant	Aquatic Life Cold Water Fishery Primary Contact Recreation

* This document only addresses the pollutant categories in bold.

All 303(d) listing probable causes shown in **bold** in **Table 1-1** are associated with sediment pollutants and will be addressed within this document. Although TMDLs address pollutant loading, implementation of land, soil, and water conservation practices to reduce pollutant loading will inherently address some pollution impairments in the listed water bodies above.

1.3 Document Description

Sediment has been shown to impair some designated uses of tributary streams of the Upper Jefferson River watershed, including aquatic life and coldwater fisheries (See **Table 1-1**). **Table 1-1** provides a summary of identified impairments for the Upper Jefferson River TPA based on the 2006 Integrated Report. DEQ recognizes there are other pollutant listings for the TPA; however, this document only addresses sediment. Because TMDLs are completed for each pollutant/water body combination, one framework water quality improvement plan, such as this, is likely to contain several TMDLs.

The document addresses all of the required components of a TMDL and includes an implementation and monitoring strategy as well as a discussion on public involvement. The main body of the document provides a summary of the TMDL components. Additional technical details are found in the Appendices. The document is organized as follows:

- Watershed Characterization: **Section 2.0**
- Application of Montana's Water Quality Standards for TMDL Development: **Section 3.0**
- Description of TMDL Components: **Section 4.0**
- Sediment – Comparison of Existing Data to Water Quality Targets, Sources and Loads, and TMDLs and Allocations: **Section 5.0**
- Restoration Objectives and Implementation Plan: **Section 6.0**
- Effectiveness Monitoring: **Section 7.0**
- Stakeholder and Public Comments: **Section 8.0**

The Appendices include:

Appendix A: Watershed Characterization Report
Appendix B: Regulatory Framework and Reference Condition Approach
Appendix C: Aerial Photo Review and Field Source Assessment
Appendix D: Sediment Contribution from Hillslope Erosion
Appendix E: Upland Sediment Loading Corrected for Existing and Potential Riparian Buffering Capacity
Appendix F: Sediment Contribution from Roads
Appendix G: Sediment Contribution from Streambank Erosion
Appendix H: Daily TMDLs
Appendix I: Response to Public Comments

SECTION 2.0
WATERSHED CHARACTERIZATION

This section includes a summary of the physical and social characteristics of the Upper Jefferson River watershed excerpted from the *Watershed Characterization Report for the Jefferson River Water Quality Restoration Planning Areas*. The entire watershed characterization report, including associated maps, is contained in **Appendix A**.

2.1 Physical Characteristics

2.1.1 Location

The Upper Jefferson watershed TMDL planning area encompasses approximately 734 square miles of land in Jefferson and Madison counties, beginning at the Jefferson River's point of origin near Twin Bridges and extending to its confluence with the Boulder River near Whitehall. The watershed area includes a dozen or more tributary streams that drain portions of the Tobacco Root Mountains to the south and the Highland Mountains to the north. Land ownership includes a mix of federal, state, and private.

2.1.2 Climate

The average precipitation ranges from 10 inches/year in the valley to 18 inches/year at higher elevations, while average snowfall ranges from 9 inches/year in the valley to 85.8 inches/year at higher elevations. May and June are consistently the wettest months of the year and winter precipitation is dominated by snowfall. Temperature patterns reveal that July is the hottest month and January is the coldest throughout the watershed. Summertime highs are typically in the high 70s Fahrenheit to low 80s F, and winter lows fall to approximately 11 degrees F.

2.1.3 Hydrology

Streamflows are at their highest between May and June, which also see the greatest amount of precipitation and snowmelt runoff. Streamflows begin to decline in late June or early July and reach minimum flow levels in September, as many streams go dry. This decrease in streamflow correlates with a dwindling water supply and increasing water demands for irrigation and other uses. About 42,000 acres, (9% of the total Upper Jefferson River watershed area) is irrigated. Streamflows begin to rebound in October and November when irrigation ends and fall storms supplement baseflow levels.

2.1.4 Geology, Soils, and Stream Morphology

The majority of soils in the Upper Jefferson watershed are moderately susceptible to erosion and produce moderate amounts of runoff. The areas of land draining to Big Pipestone, Little Pipestone, Halfway, Whitetail, and Fitz creeks is dominated by the granitic Boulder Batholith, which is nutrient-poor and highly erodible, contributing to a naturally high sediment supply in these streams.

Many tributary streams have been historically straightened, or channelized, to accommodate a variety of land uses and/or transportation networks. These alterations can have significant effects on sediment transport dynamics of streams and may affect stability of streambanks.

2.2 Social Characteristics

2.2.1 Land Ownership

Private land dominates the Upper Jefferson watershed, with 44.7% in private ownership. U.S. Forest Service lands account for 38.6% of the area, while the U.S. Bureau of Land Management controls another 11.5%, and the state owns 4.7% (including water). The remaining minor portion falls under U.S. Fish and Wildlife Service designation.

2.2.2 Land Use and Land Cover

Evergreen forest (national and other forested lands) is the dominant land use at higher elevations in the watershed, comprising 40.83% of the watershed area. Grass rangelands comprise 37.76% of the land area, while crop and pasturelands make up 11.86%. Brush rangeland and mixed rangeland total an additional combined 5.79% of the land area.

Land cover is dominated by a combination of grassland types (40.03%). A mix of several forest types, including Douglas-fir, mixed xeric forest, lodgepole pine, and mixed subalpine and whitebark pine, accounts for 38.6% of the land cover in the watershed. Sagebrush accounts for 6.6%, dry and irrigated agricultural lands 4.61%, and montane parklands and subalpine meadows 3.22% of the watershed. The remaining 7% of land area consists of minor amounts of 19 different vegetation types.

2.2.3 Population

The main towns in the Upper Jefferson River watershed include Twin Bridges in the south and Whitehall in the north. Twin Bridges' population increased from 374 in 1990 to 400 in 2000, while Whitehall had a slight decrease in population from 1,067 in 1990 to 1,044 in 2000. Twenty-four percent of the combined labor force of both towns work in construction, extraction, and maintenance occupations, while 23% work in management and professional occupations. Sales and office occupations employ 19%. Service occupations employ 14% of workers, and production, transportation, and material moving industries employ 13%. Seven percent of workers in Twin Bridges and Whitehall are employed in farming, fisheries, and forestry occupations.

2.3 Fish and Aquatic Life

Two fish species occurring within the Upper Jefferson River watershed, the Westslope cutthroat trout (*Oncorhynchus clarki lewisi*) and the Montana arctic grayling (*Thymallus arcticus montanus*), are listed by the state as species of special concern. Westslope cutthroat trout are thought to occur in five streams, including four that appear on the 303(d) list. These include Halfway Creek, Fish Creek, Cherry Creek, and Hells Canyon Creek. Genetically pure populations of Westslope cutthroat trout are thought to be limited to Halfway and Fish creeks. The present distribution of Montana fluvial arctic grayling in the Upper Jefferson watershed is not well known. However, grayling may be present in the Jefferson River mainstem as a result of an attempt to reestablish a population in the lower Beaverhead River upstream of the confluence of the Beaverhead and Big Hole rivers.

SECTION 3.0
APPLICATION OF MONTANA'S WATER QUALITY STANDARDS FOR TMDL DEVELOPMENT

The goal of the federal Clean Water Act is to ensure that the quality of all surface waters is capable of supporting all designated uses. Water quality standards also form the basis for impairment determinations for Montana's 303(d) list, TMDL water quality improvement goals, formation of TMDLs and allocations, and standards attainment evaluations. The Montana water quality standards include four main parts: 1) stream classifications and designated uses, 2) numeric and narrative water quality criteria designed to protect the designated uses, 3) non-degradation provisions for existing high quality waters, and 4) prohibitions of various practices that degrade water quality. The components applicable to this document are reviewed briefly below. More detailed descriptions of the Montana water quality standards that apply to the Upper Jefferson TPA can be found in **Appendix B**.

3.1 Upper Jefferson Watershed Stream Classifications and Designated Beneficial Uses

Classification is the designation of a single use, or group of uses, to a water body based on the potential of the water body to support those uses. All Montana waters are classified for multiple beneficial uses. All streams and lakes within the Upper Jefferson watershed are classified B-1, which specifies that all of the following uses must be supported: drinking, culinary, and food processing purposes after conventional treatment; bathing, swimming, and recreation; growth and propagation of salmonid fishes and associated aquatic life, waterfowl, and furbearers; and agricultural and industrial water supply. On the 2006 303(d) List, 8 water body segments are listed as not supporting one or more beneficial uses (**Table 3-1**).

While some of the Upper Jefferson watershed streams might not actually be used for a specific purpose (e.g., drinking water supply), the quality of the water must be maintained at a level that can support that use to the best extent possible based on a stream's natural potential. More detailed descriptions of Montana's surface water classifications and designated beneficial uses are provided in **Section B.2 of Appendix B**.

Table 3-1. Tributary Water Bodies in the Upper Jefferson River TPA from the 2006 303(d) List and their Associated Level of Beneficial Use-Support.

Water body & Stream Description	Water body #	Use Class	Year	Aquatic Life	Coldwater Fishery	Drinking Water	Contact Recreation	Agriculture	Industry
Big Pipestone Creek, from headwaters to mouth (Jefferson River)	MT41D001_020	B-1	2006	P	P	F	P	F	P
Cherry Creek, from headwaters to mouth (Jefferson River)	MT41D002_090	B-1	2006	N	N	F	N	F	F
Fish Creek, from headwaters to mouth (Jefferson River)	MT41D003_070	B-1	2006	N	N	F	N	F	F
Fitz Creek, from headwaters to mouth (Whitetail Creek)	MT41D002_030	B-1	2006	N	N	F	N	F	F
Halfway Creek, from headwaters to mouth (Big Pipestone Creek)	MT41D003_130	B-1	2006	P	P	F	F	F	F
Hells Canyon Creek, from headwaters to mouth (Jefferson River)	MT41D003_030	B-1	2006	P	P	F	P	F	F
Little Pipestone Creek, from headwaters to mouth (Big Pipestone Creek)	MT41D003_220	B-1	2006	P	P	F	F	F	F
Whitetail Creek, from headwaters to mouth (Jefferson River)**	MT41D003_050	B-1	2006	P	P	F	P	F	F

F = Full Support, P = Partial Support, N = Not Supported, T = Threatened, X = Not Assessed (Lacking Sufficient Credible Data)

3.2 Water Quality Standards

In addition to the use classifications described above, Montana's water quality standards include numeric and narrative criteria that are designed to protect the designated uses. For the sediment TMDL development process in the Upper Jefferson River TPA, only the narrative standards are applicable.

Narrative standards have been developed for substances or conditions where sufficient data on the long and/or short-term effects do not exist or for pollutants whose effects must be assessed on a site-specific basis. Narrative standards describe either the allowable condition or an allowable increase of a pollutant over "naturally occurring" conditions or pollutant levels. DEQ uses a reference condition (naturally occurring condition) to determine whether or not narrative standards are being achieved.

Reference condition is defined as the condition a water body could attain if all reasonable land, soil, and water conservation practices were put in place. Reasonable land, soil, and water

conservation practices usually include, but are not limited to, best management practices (BMPs).

The specific sediment narrative water quality standards that apply to the Upper Jefferson River watershed are summarized below. More detailed descriptions of Montana's surface water standards are provided in **Section B.2 of Appendix B**.

3.2.1 Sediment Standards

Sediment (i.e., coarse and fine bed sediment) and suspended sediment are addressed via the narrative criteria identified in **Table 3-2.** The relevant narrative criteria do not allow for harmful or other undesirable conditions related to increases above naturally occurring levels or from discharges to state surface waters. In other words, water quality goals should aim for condition in which any increases in sediment above naturally occurring levels are not harmful, detrimental, or injurious to beneficial uses (see definitions in **Table 3-2)**.

Table 3-2. Applicable Rules for Sediment Related Pollutants

Rule(s)	Standard
17.30.622(3) & 17.30.623(2)	No person may violate the following specific water quality standards for waters classified A-1 or B-1.
17.30.602(19)	"Naturally occurring" means conditions or material present from runoff or percolation over which man has no control or from developed land where all reasonable land, soil, and water conservation practices have been applied. Conditions resulting from the reasonable operation of dams in existence as of July 1, 1971, are natural.
17.30.602(24)	"Reasonable land, soil, and water conservation practices" refers methods, measures, or practices that protect present and reasonably anticipated beneficial uses. These practices include, but are not limited to, structural and nonstructural controls and operation and maintenance procedures. Appropriate practices may be applied before, during, or after pollution-producing activities.
17.30.622(3)(f) & 17.30.623(2)(f)	No increases are allowed above naturally occurring concentrations of sediment or suspended sediment (except a permitted in 75-5-318, MCA), settleable solids, oils, or floating solids, which will or are likely to create a nuisance or render the waters harmful, detrimental, or injurious to public health, recreation, safety, welfare, livestock, wild animals, birds, fish, or other wildlife.
17.30.622(3)(d)	No increase above naturally occurring turbidity or suspended sediment is allowed in A-1 except as permitted in 75-5-318, MCA.
17.30.623(2)(d)	The maximum allowable increase above naturally occurring turbidity is 5 NTU for B-1 except as permitted in 75-5-318, MCA.
17.30.637(1)(a & d)	State surface waters must be free from substances attributable to municipal, industrial, agricultural practices or other discharges that will: (a) settle to form objectionable sludge deposits or emulsions beneath the surface of the water or upon adjoining shorelines; (b) create concentrations or combinations of materials that are toxic or harmful to human, animal, plant, or aquatic life.

SECTION 4.0
DESCRIPTION OF TMDL COMPONENTS

A TMDL is basically a loading capacity for a particular water body and refers to the maximum amount of a pollutant a stream or lake can receive and still meet water quality standards. A TMDL is also a reduction in pollutant loading resulting in attainment of water quality standards. More specifically, a TMDL is the sum of waste load allocations (WLAs) for point sources, and load allocations (LAs) for nonpoint sources and natural background sources. In addition, the TMDL includes a margin of safety (MOS) that accounts for the uncertainty in the relationship between pollutant loads and the quality of the receiving stream. The allowable pollutant load must ensure that the water body will be able to attain and maintain water quality standards regardless of seasonal variations in water quality conditions, streamflows, and pollutant loading. TMDLs are expressed by the following equation:

$$\text{TMDL} = \Sigma\text{WLA} + \Sigma\text{LA} + \text{MOS}$$

Section 5 includes all 303(d) listings specific to sediment, the source assessment process for that pollutant, relevant water quality targets, a comparison of existing conditions to targets, quantification of loading from identified sources, TMDLs, and allocations to sources. The major components that figured into TMDL development are described below.

4.1 Establishing and Evaluating Targets

Because loading capacity is evaluated in terms of meeting water quality standards, quantitative water quality targets and supplemental indicators are developed to help assess the condition of the water body relative to the applicable standard(s) and to help determine successful TMDL implementation. This document outlines water quality targets for sediment, the pollutant of concern, in tributary streams of the Upper Jefferson TPA. TMDL water quality targets help translate the numeric or narrative water quality standards for the pollutant of concern. For pollutants with established numeric water quality standards, the numeric values are used as TMDL water quality targets. For pollutants with only narrative standards, such as sediment, the water quality targets help to further interpret the narrative standard and provide an improved understanding of impairment conditions. Water quality targets typically include a suite of instream measures that link directly to the impacted beneficial use(s) and applicable water quality standard(s). The water quality targets help define the desired stream conditions and are used to provide benchmarks to evaluate overall success of restoration activities.

4.2 Quantifying Pollutant Sources

All significant pollutant sources, including natural background loading, are quantified so that the relative pollutant contributions can be determined. Because water quality impacts can vary throughout the year, often source assessments must evaluate the seasonal nature and ultimate fate of the pollutant loading. The source assessment usually helps further define the extent of the problem by putting human-caused loading into context with natural background loading.

A pollutant load is usually quantified for each point source permitted under the Montana Pollutant Discharge Elimination System (MPDES) program. Most other pollutant sources, typically referred to as nonpoint sources, are quantified by source categories, such as unpaved roads, and/or by land uses, such as crop production or forestry. These source categories or land uses can be further divided by ownership such as federal, state, or private. Alternatively, a sub-watershed (or tributaries) approach can be used whereby most or all sources are combined for quantification purposes.

The source assessments are performed at a watershed scale because all potentially significant sources of the water quality problems must be evaluated. The source quantification approaches may range from reasonably accurate estimates to gross allotments, depending on the availability of data and appropriate techniques for predicting the loading (40CFR Section 130.2(I)). Montana TMDL development often includes a combination of approaches, depending on the level of desired certainty for setting allocations and guiding implementation activities.

Figure 4-1 is a schematic diagram illustrating how numerous sources contribute to the existing load and how a TMDL is determined by comparing the existing load to that which will meet standards.

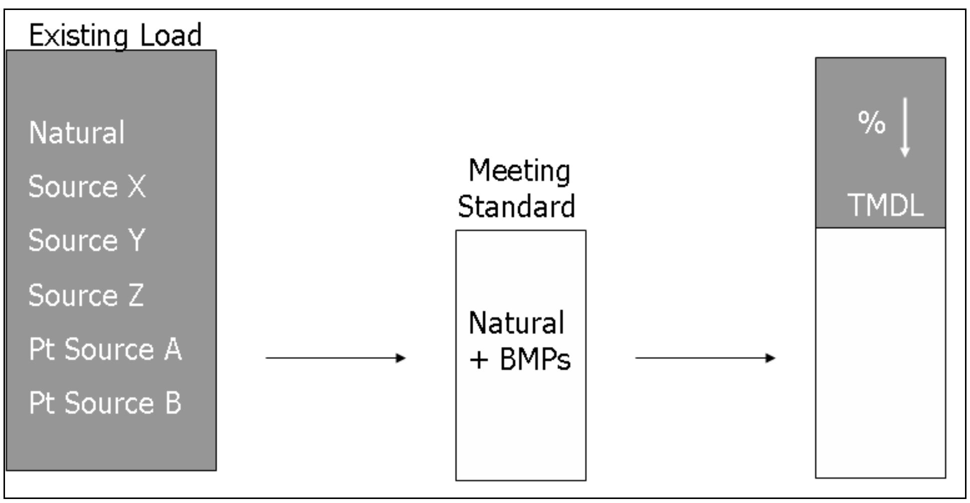

Figure 4-1. Schematic example of TMDL development.

4.3 Determining Allocations

Once the loading capacity (i.e., TMDL) is determined, that total must be divided, or allocated, among the contributing sources. Allocations are determined by quantifying feasible and achievable load reductions associated with the application of reasonable land, soil, and water conservation practices. Reasonable land, soil, and water conservation practices generally include BMPs, but additional conservation practices may be required to achieve compliance with water quality standards and restore beneficial uses. **Figure 4-2** contains a schematic diagram of how TMDLs are allocated to different sources using WLAs for point sources and LAs for natural and nonpoint sources. Under the current regulatory framework for development of TMDLs, flexibility is allowed for specifying allocations in that "TMDLs can be expressed in terms of either mass per time, toxicity, or other appropriate measure." Allocations are typically expressed

as a number, a percent reduction (from the current load), or as a surrogate measure, such as a percent increase in canopy density for temperature TMDLs.

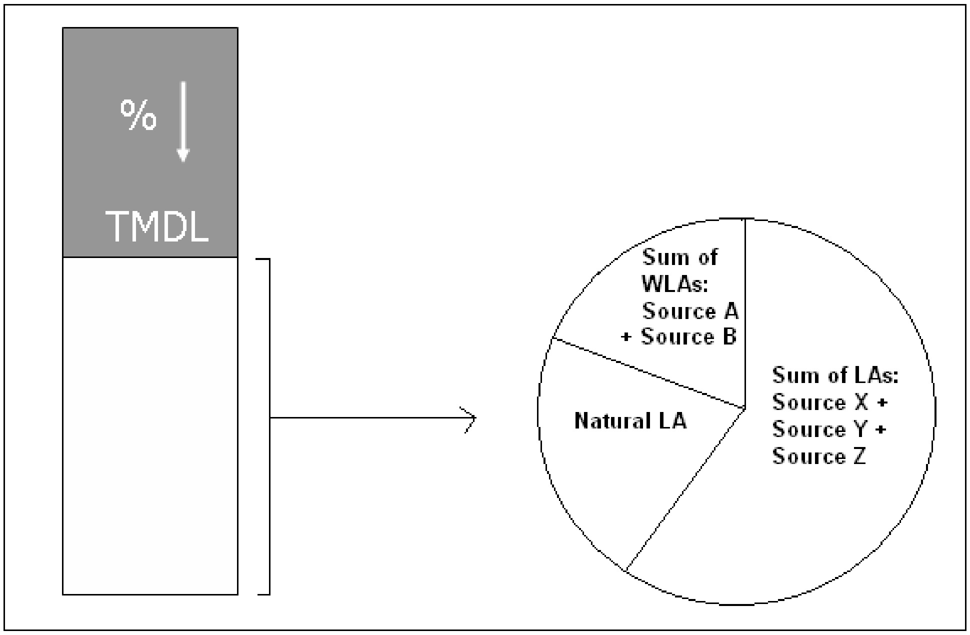

Figure 4-2. Schematic diagram of TMDL and allocations.

4.4 Margin of Safety

Incorporating a margin of safety (MOS) is a required component of TMDL development. The MOS accounts for the uncertainty between pollutant loading and water quality and is intended to ensure that load reductions and allocations are sufficient to sustain conditions that will support beneficial uses. The MOS may be applied implicitly by using conservative assumptions in the TMDL development process or explicitly by setting aside a portion of the allowable loading (EPA, 1999). The TMDLs within this document incorporate an implicit MOS in a variety of ways that are discussed in greater detail in **Section 5.8**.

SECTION 5.0
SEDIMENT

This portion of the document focuses on sediment as an identified cause of water quality impairments in the Upper Jefferson TPA. It describes: 1) the mechanisms by which sediment impairs beneficial uses of those streams, 2) the specific stream segments of concern, 3) the available data pertaining to sediment impairments in the watershed, 4) the various contributing sources of sediment based on recent studies, and 5) the sediment TMDLs and allocations.

5.1 Mechanism of Effects of Excess Sediment on Beneficial Uses

Weathering and erosion of land and transport of sediment to and by streams are important natural phenomena that help build and maintain streambanks and floodplains. However, excessive erosion, or the absence of natural sediment barriers and filters such as riparian vegetation, woody debris, beaver dams, and overhanging vegetation, can lead to high levels of suspended sediment and sediment deposits in areas not naturally containing high levels of fine sediment.

Uncharacteristically high amounts of sediment in streams can impair habitat for aquatic life and coldwater fisheries as well as beneficial uses for recreation and drinking water. Excess suspended sediment can increase filtration costs for water treatment facilities, decrease recreational use potential, and impair aesthetic values. Fish and other aquatic life are typically the most sensitive to excess sediment. High levels of suspended sediment can reduce light penetration through water, which may limit growth of algae and aquatic plants. This decline in primary producers could result in a decline in aquatic insect populations, which may also be affected if deposited sediment obscures food, habitat, hiding places, and nesting sites. Excess sediment can also impair biological processes and reproductive success of individual aquatic organisms by clogging gills and causing abrasive damage, reducing spawning sites, and smothering eggs or hatchlings. An accumulation of fine sediment on stream bottoms can also reduce water flow through gravels harboring incubating eggs, hinder the emergence of newly hatched fish, deplete the oxygen supply to embryos, and cause metabolic wastes to accumulate around embryos, killing them.

5.2 Stream Segments of Concern

A total of eight tributary water body segments in the Upper Jefferson TPA appeared on the 2006 Montana 303(d) List due to sediment impairments (**Table 5-1**). These include Big Pipestone, Little Pipestone, Cherry, Fish, Fitz, Halfway, Hells Canyon, and Whitetail creeks. Pollutant listing causes include sedimentation/siltation and suspended solids. As shown in **Table 5-1**, many of the water bodies with sediment impairments are also listed for habitat and flow alterations, which are forms of pollution frequently associated with sediment impairment. TMDLs are limited to pollutants, but implementation of land, soil, and water conservation practices to reduce pollutant loading will inherently address some pollution impairments.

Table 5-1. Water Body Segments with Sediment Listings and Possible Sediment-related Listings on the 2006 303(d) List

Stream Segment	Water Body #	Sediment and Potentially Related Causes of Impairment
Big Pipestone Creek, from headwaters to mouth (Jefferson River)	MT41D001_020	Suspended solids & physical substrate habitat alterations*
Cherry Creek, from headwaters to mouth (Jefferson River)	MT41D002_090	Sedimentation / siltation, Physical substrate habitat alterations* & flow alterations*
Fish Creek, from headwaters to mouth (Jefferson River)	MT41D003_070	Sedimentation/ siltation, physical substrate habitat alterations* & flow alterations*
Fitz Creek, from headwaters to mouth (Whitetail Creek)	MT41D002_030	Sedimentation/ siltation & physical substrate habitat alterations*
Halfway Creek, from headwaters to mouth (Big Pipestone Creek)	MT41D003_130	Sedimentation/ siltation & physical substrate habitat alterations*
Hells Canyon Creek, from headwaters to mouth (Jefferson River)	MT41D003_030	Sedimentation/ siltation, physical substrate habitat alterations* & flow alterations*
Little Pipestone Creek, from headwaters to mouth (Big Pipestone Creek)	MT41D003_220	Sedimentation/ siltation & physical substrate habitat alterations*
Whitetail Creek, from headwaters to mouth (Jefferson River)	MT41D003_050	Sedimentation/ siltation, physical substrate habitat alterations* & flow alterations*

*Form of pollution frequently linked to sediment impairment.

5.3 Information Sources and Assessment Methods

Sources used to develop the TMDL components include information from DEQ assessment files used to make impairment determinations and data collected and/or obtained during the TMDL development process. Physical, biological, and habitat data were collected by DEQ on most water bodies between 1999 and 2003. Additionally, field measurements of channel morphology and riparian and instream habitat parameters were collected in 2004 and 2005 from 20 reaches on 11 water bodies to aid in TMDL development. The focus of the 2005 Upper Jefferson River TPA Sediment and Stream Morphology Project was to apply the 2004 aerial photo interpretation results and preliminary pollution source assessment to direct physical sampling for suspected and confirmed sediment-impaired stream segments in the upper Jefferson Watershed (DEQ, 2005a & DEQ, 2006). Water quality monitoring and assessments were intended to characterize instream sediment conditions and bank erosion for 303(d) listed stream segments in the Upper Jefferson watershed. The field parameters assessed in 2005 include standard measures of stream channel morphology, stream habitat, riparian vegetation, and near-stream land use. The aerial and field assessments are described in more detail in the *Upper Jefferson River Water Quality Monitoring*

Project Quality Assurance Project Plan (DEQ, 2005b). Field parameters are briefly described in **Section 5.4**, and summaries of all field data are contained in the 2005 and 2006 monitoring summary reports (DEQ, 2005a & DEQ, 2006).

Significant sediment sources identified within the Upper Jefferson TPA that were assessed for the purposes of TMDL development include:

- point sources
- upland erosion and riparian health
- unpaved roads
- gully and rill erosion from I-90
- streambank erosion

For each impaired water body segment, sediment loads from each source category were estimated based on field surveys, watershed modeling, and load extrapolation techniques (described below). Additional details about the source assessment approach are contained in the *Upper Jefferson River Water Quality Monitoring Project Quality Assurance Project Plan* (DEQ, 2004). The complete methods and results for source assessments for upland erosion, unpaved roads, and streambank erosion are located in **Appendices D, E, F,** and **G.**

5.3.1 Sediment Loading due to Point Sources

Point sources of sediment in the tributaries of the Upper Jefferson TPA evaluated in this assessment include the town of Whitehall's domestic wastewater treatment facility's municipal permit and the Conda Mining, Inc., storm water permit.

Whitehall has a wastewater treatment lagoon that continuously discharges into Big Pipestone Creek. The town's annual average TSS load contribution was calculated using monthly TSS and discharge measurements from 1998-2007 (n=93). The average TSS contribution from this source was 6 tons of TSS per year, discharging directly to Big Pipestone Creek. This waste load represents <0.10% of the overall sediment yield assessed in the Big Pipestone Creek watershed. As such, the allocation and load reductions will be based solely upon Montana Pollutant Discharge Elimination System (MPDES) permit requirements.

The Conda Mining facility has a MPDES storm water permit that regulates the direct discharge of storm water draining the facility and its grounds. Based upon permit review, the discharge monitoring reports show that no discharges have occurred at this facility. The fact that no discharge has been reported, and in conjunction with the current use of sediment BMPs on site, the Conda Mining facility is deemed an insignificant source of sediment within the Big Pipestone watershed, giving it a waste load allocation of zero.

5.3.2 Modeled Upland Erosion and Riparian Buffering Capacity

Upland sediment loading due to hillslope erosion was modeled using the Universal Soil Loss Equation (USLE). Sediment delivery to the stream was predicted using a sediment delivery ratio. The USLE results are useful for source assessment as well as for determining allocations for human-caused upland erosion. This model provided an estimate of existing sediment loading from upland sources and an estimate of potential sediment loading reductions by applying best management practices (BMPs). Because the plant canopy and type of tillage practices can influence erosion, potential load reductions are calculated by adjusting factors within the model associated with land management and cropping practices (C-factors). Additional information on the upland erosion modeling can be found in *Sediment Contribution from Hillslope Erosion* (**Appendix D**).

The Upland USLE-based modeling effort did not, however, take into account the effect that vegetated riparian buffers have on reducing the upland sediment load delivered to streams. Because of this, a secondary effort was undertaken to qualify existing and potential riparian health and its associated effect on existing and potential upland sediment loads to the 303(d) listed tributaries of the Upper Jefferson TMDL Planning Area (TPA); it is presented in *USLE Based Upland Sediment Loading Corrected for Existing and Potential Riparian Buffering Capacity* (**Appendix E**).

Supplemental to the modeling scenarios developed for the upland USLE model, this secondary effort provides an additional assessment of the existing sediment loading from modeled upland sources routed through the existing riparian buffer condition. In addition it provides for an assessment of potential sediment loading reductions gained through BMPs, to those activities whose actions within the near-stream riparian environment have the potential to affect the buffering capacity (i.e., sediment reduction efficiency) of the vegetated riparian buffer.

The sediment load allocation strategy for upland erosion sources provides for a potential decrease in loading through BMPs in upland land uses, as well as those land management activities that have the potential to affect the overall heath and/or buffering capacity of the vegetated riparian buffer. A more detailed description of the assessment can be found in *Sediment Contribution from Hillslope Erosion* (DEQ, 2007) (**Appendix D**) and *USLE Based Upland Sediment Loading Corrected for Existing and Potential Riparian Buffering Capacity* (**Appendix E**).

5.3.3 Unpaved Road Sediment Assessment

Sediment loading from unpaved roads was assessed using GIS, field data collection, and sediment modeling. Each identified unpaved road crossing and near-stream road segment was assigned attributes for road name, surface type, road ownership, stream name, subwatershed, and landscape type (i.e., mountain, foothill, or valley). Sixty crossings and 23 near-stream segments representing the range of conditions within the watershed were field assessed in 2006, and sediment loading was estimated using the Water Erosion Prediction Project Methodology (WEPP:Road). The average sediment contribution from unpaved road crossings and near-stream road segments were extrapolated to all unpaved roads in the watershed based on landscape type.

To address sediment from unpaved roads in the TMDLs and allocations that follow in **Section 5.6**, the WEPP:Roads analysis was also run using BMPs to reduce the road contributing length. A more detailed description of this assessment can be found in *Unpaved Road Sediment Assessment* (DEQ, 2007) (**Appendix F**).

5.3.4 Sediment Loading due to Gully Wash and Rill Erosion along Interstate 90

The transport and input of gully wash and rill erosion was assessed along Homestake Creek, tributary to Big Pipestone Creek, adjacent to Interstate 90 (I-90). In his student thesis titled *Hydrology, Water Quality, and Sediment transport Rates in the Pipestone Creek Watershed, Jefferson County, Montana*, Berger (2004) attempted to semi-quantify the volume of sediment produced from sources associated with I-90. He estimated that the approximate volume of sediment entering Homestake Creek from I-90 sources was roughly 500 cubic feet or 21 tons (assuming a bulk density of 1.44 tons/cubic yard). However, he also stated that due to the high rates of bedload transport in the stream, it is likely that this total was significantly underestimated. Berger's study noted that these sediment inputs were dominated by four large sources that were traced to uncontrolled runoff from I-90 and subsequent gullying and rill erosion of steep hillslopes leading down to Homestake Creek.

In the TMDLs and allocations that follow, a 10% reduction in the human-caused sediment load from I-90 sources is proposed. The Montana Department of Transportation will explore alternatives for diverting road runoff from sensitive areas and capturing sediment. Additionally, BMPs may be used to prevent delivery of road materials, including gully wash, rill erosion, and road traction sanding, to Homestake Creek. BMPs could include planting vegetation buffers, routing flows away from streams, and creating sediment traps. Loading from gully wash and rill erosion will be considered in developing sediment loads, allocations, and potential reductions. Road traction sanding also has the potential to produce a sediment load. Though not included in this allocation strategy, it is recommended that road traction sanding be evaluated through adaptive management and monitoring.

5.3.5 Eroding Streambank Sediment Assessment

Sediment loading from eroding streambanks was assessed by performing Bank Erosion Hazard Index (BEHI) measurements and evaluating the Near Bank Stress (NBS) (Rosgen 1996, 2004) along monitoring reaches in 2005. BEHI scores were determined at each eroding streambank based on the following parameters: bank height, bankfull height, root depth, root density, bank angle, and surface protection. In addition to BEHI data collection, the source of streambank erosion was evaluated based on observed human-caused disturbances and the surrounding land-use practices based on the following near-stream source categories:

- transportation
- riparian grazing
- cropland
- mining
- silviculture
- irrigation-shifts in stream energy

- natural sources
- other

Streambank erosion data from the 2005 monitoring was extrapolated to the stream reach, stream segment, and watershed scales. The potential for sediment load reduction at the stream segment scale was estimated as a percent reduction that could be achieved if all eroding streambanks could be reduced to a moderate BEHI score. A more detailed description of this assessment can be found in *Streambank Erosion Source Assessment,* which is included as **Appendix G**.

5.3.6 Uncertainty

A degree of uncertainty is inherent in any study of watershed processes related to sediment. Sediment limitations in many streams in the Upper Jefferson TPA relate to a fine sediment fraction found on the stream bottom, while sediment modeling used in the Upper Jefferson TPA examined all sediment sizes. In general, roads and uplands produce mostly fine sediment loads, while streambank erosion can produce all sediment sizes. Because sediment source modeling may under- or over-estimate natural inputs due to selection of sediment monitoring sections and the extrapolation methods used, model results are not an accurate account of sediment production within each watershed. Instead, source assessment model results are used as a tool to estimate sediment loads and make general comparisons of sediment loads from various sources. Due to the uncertainty with modeling, this TMDL document will include a monitoring and adaptive management plan (**Section 7**) to account for such uncertainties in the source assessment results.

5.4 Water Quality Targets and Comparison to Existing Conditions

This section summarizes water quality targets and compares them with available data for the tributary stream segments of concern in the Upper Jefferson TPA (**Table 5-1**). Although placement on the 303(d) list indicates impaired water quality, a comparison of water quality targets with existing data helps define the level of impairment and guide the development of TMDL allocations. It also establishes a starting point from which to measure future water quality restoration success.

5.4.1 Water Quality Targets

For the tributary streams of the Upper Jefferson TPA, a suite of water quality targets and supplemental indicators are presented to assess the effect of sediment derived from human-caused sources on beneficial use support. Water quality targets and supplemental indicators for sediment impairments include measures of the width/depth ratio, entrenchment ratio, percent of fine sediment on the stream bed and in pool tail-outs, eroding banks, residual pool depths, pool frequency, large woody debris frequency, riparian condition, and biological metrics. Future surveys should document stable (if meeting criterion) or improving trends. The proposed water quality targets and supplemental indicators for sediment impairments are summarized in **Table 5-2** and are described in detail in the sections that follow. If the results are consistent with the existing impairment determinations, a TMDL will be provided. Site-specific conditions such as recent wildfires, natural conditions, and flow alterations within a watershed may warrant the

selection of unique indicator values that differ slightly from those presented below, or special interpretation of the data relative to the proposed sediment indicator values.

Table 5-2. Targets and Supplemental Indicators for Sediment in Tributary Stream of the Upper Jefferson TPA

Water Quality Targets	**Proposed Criterion**
Percentage of fine surface sediment <6mm based on the reach composite pebble count.	Comparable with reference values based on Rosgen Stream type. [a]
Percentage of fine surface sediment <2mm based on the reach **average** riffle pebble counts.	The reach average value must not exceed 20%. This target shall not apply to low gradient E type streams with natural silt or sand substrates. Future surveys should document stable or improving trends.
Percentage of subsurface fines < 6.4 mm size class, expressed as a reach **average**, in McNeil core samples collected in trout spawning gravel beds.	The reach average value must not exceed 30%. [b] Future surveys should document stable or improving trends.
Percentage of subsurface fines < 0.85 mm size class, expressed as a reach **average**, in McNeil core samples collected in trout spawning gravel beds.	The reach average value must not exceed 10%. Future surveys should document stable or improving trends.
Width/depth ratio, expressed as a reach **median** from channel cross-section measurements.	Comparable with reference values. [a]
Entrenchment ratio, expressed as a reach **median** from channel cross-section measurements.	Comparable with reference values. [a] This target only applies to B, C, and E stream types. An entrenchment ratio >5 will be considered to meet the water quality target for C channels and >3.7 for E channels.
Supplemental Indicators	Proposed Criterion
BEHI hazard rating, expressed as a reach **average**.	Comparable with reference values based on Rosgen Stream type. [a]
Percentage of eroding banks, based on the sum of both left and right bank lengths per reach.	Non-eroding banks for at least 85% of reach for A, E, B, and C type streams. Future surveys should document stable or improving trends.
Proper Functioning Condition (PFC) riparian assessment.	"Proper Functioning Condition" or "Functional-at Risk" with an upward trend and the intent of reaching "Proper Functioning Condition".
Anthropogenic sediment sources.	No significant sources identified based on field and aerial surveys.
Macroinvertebrates	Mountain MMI > 63 Valley MMI > 48 0.80 < RIVPACS < 1.2

Table 5-2. Targets and Supplemental Indicators for Sediment in Tributary Stream of the Upper Jefferson TPA

Water Quality Targets	Proposed Criterion
Pool frequency and average residual pool depth per reach.	Until appropriate reference conditions are identified, 2005 inventory values shall provide benchmarks for future surveys. Future surveys should document stable or improving trends.
Greenline survey.	≥ 49% understory shrub cover

[a] Based on the Beaverhead-Deerlodge National Forest channel morphology dataset and applies only to Jefferson River tributary streams.
[b] Based on the Helena National Forest McNeil Core dataset.

Several of the water quality targets for sediment in the Upper Jefferson TPA are based on regional reference data. Note: DEQ defines "reference" as the condition of a water body capable of supporting its present and future beneficial uses when all reasonable land, soil, and water conservation practices have been applied. In other words, reference condition reflects a water body's greatest potential for water quality given historic and current land use activities. Water bodies used to determine reference conditions are not necessarily pristine or perfectly suited to giving the best possible support to all possible beneficial uses. In addition, this reference condition approach is not an effort to "turn back the clock" to conditions that may have existed before human settlement but is intended to accommodate natural variations due to climate, bedrock, soils, hydrology, and other natural physiochemical differences when establishing threshold values for sediment indicators. The intention is to differentiate between natural conditions and widespread or significant alterations of biology, chemistry, or hydrogeomorphology due to human activity.

Channel Morphology and Substrate Measurements
The channel morphology dataset compiled by Pete Bengeyfield of the U.S. Forest Service was used to develop several water quality targets in the Upper Jefferson TPA. This dataset includes regional reference data derived from the Beaverhead-Deerlodge National Forest and the Greater Yellowstone Area and includes nearly 300 surveys in the Big Hole watershed and more than 650 surveys in the south zone of the Beaverhead-Deerlodge National Forest between 1991 and 2002.

The Beaverhead-Deerlodge National Forest channel morphology surveys were compiled into a channel morphology reference dataset based on approximately 200 reference sites. Approximately 70 of the reference sites were from the Greater Yellowstone Area, while the remaining sites were surveyed within the Beaverhead-Deerlodge National Forest. Streams described as "reference" were not necessarily in pristine watersheds, though the streams had to be stable and in "proper functioning condition." Streams that shifted a Level I Rosgen classification value (e.g., E to C) were reported as "non-functioning" and were not included in the reference dataset (Bengeyfield, 2004). The entire reference dataset is available upon request from the Beaverhead-Deerlodge National Forest and has been provided to DEQ.

Water quality targets for the percent of fine sediment are <6mm, channel width/depth ratio, entrenchment ratio, and the Bank Erosion Hazard Index (BEHI) rating are based on the Beaverhead-Deerlodge National Forest channel morphology reference dataset. The 75th

percentile was calculated from the reference dataset and will be used as a basis for sediment water quality targets (**Table 5-3**). Since the water quality target depends on the stream type, the term "comparable to reference values" should be interpreted as "less than or equal to" the 75th percentile for the percent surface fines, width/depth ratio, and BEHI. "Comparable to reference values" should be interpreted as "greater than or equal to" the 75th percentile for the entrenchment ratio and sinuosity. In essence, lower values for surface fine sediment, width/depth ratio, and BEHI rating are more desirable and suggest support of the coldwater fishery and aquatic life beneficial uses. In general, higher values are desirable for the entrenchment ratio and sinuosity, though entrenchment ratio indicators will not be applied to streams that are naturally A types, since these stream types, by definition, are entrenched. In addition, no fine sediment indicators will be applied to streams that are naturally E5 or E6 types, since these stream types naturally have high amounts of fine sediment.

Table 5-3. Beaverhead-Deerlodge National Forest Reference Dataset 75th Percentiles for Individual Rosgen Stream Types.

Parameter	A	B3	B4	B	C3	C4	C	E3	E4	E5	Ea	E
% surface fines < 6mm	24	12	25	20	14	29	29	20	38	NA	40	44
Width/Depth Ratio	10	15	17	16	31	20	23	10	7	4	7	7
Entrenchment Ratio	NA	1.8	1.9	1.8	5.1	5.1	5.1	3.7	3.7	3.7	3.7	3.7
Sinuosity	1.1	1.2	1.3	1.2	1.3	1.7	1.5	1.3	1.8	1.9	1.4	1.7
Reach Average BEHI	24.2	27.1	31.7	29.7	26.9	26.5	26.5	26.3	24.2	22.0	22.7	23.6

Reference values for the percent of fine subsurface sediment measured with a McNeil core sampler are based on an extensive dataset acquired from the Helena National Forest, as well as existing TMDL standards adopted within other Montana watersheds (Lake Helena, Upper Flathead, and Deep Creek TPAs). The Helena National Forest lies immediately to the north of the Upper Jefferson watershed and displays many similar terrain features, in particular, granite-dominated watersheds of the Boulder Batholith. Since 1986 the Helena National Forest has been collecting McNeil core data from spawning gravel beds in streams supporting salmonid fisheries. Their dataset is available upon request from the forest and has been provided to DEQ.

More than 500 McNeil cores have been collected from salmonid fishery streams located within various land types and geologies. In an attempt to discern patterns of subsurface percent fines by geologies, specifically that of granite-dominated watersheds, the Helena National Forest dataset was broken into four major geomorphic groups: alluvial (n = 80), glacio-fluvial (alluvial outwash, n = 232), granitic (n = 49), and belt (metasediments, n = 153) land types (**Figure 5-1**). Box plots of the data groups reveal that percent fines among the four geomorphic groups are fairly normally distributed and have similar mean values. A one-way ANOVA (analysis of variance) test confirms this observation (significance value = 0.445) and, thus, the proposed water quality indicators have been chosen independently of watershed geology.

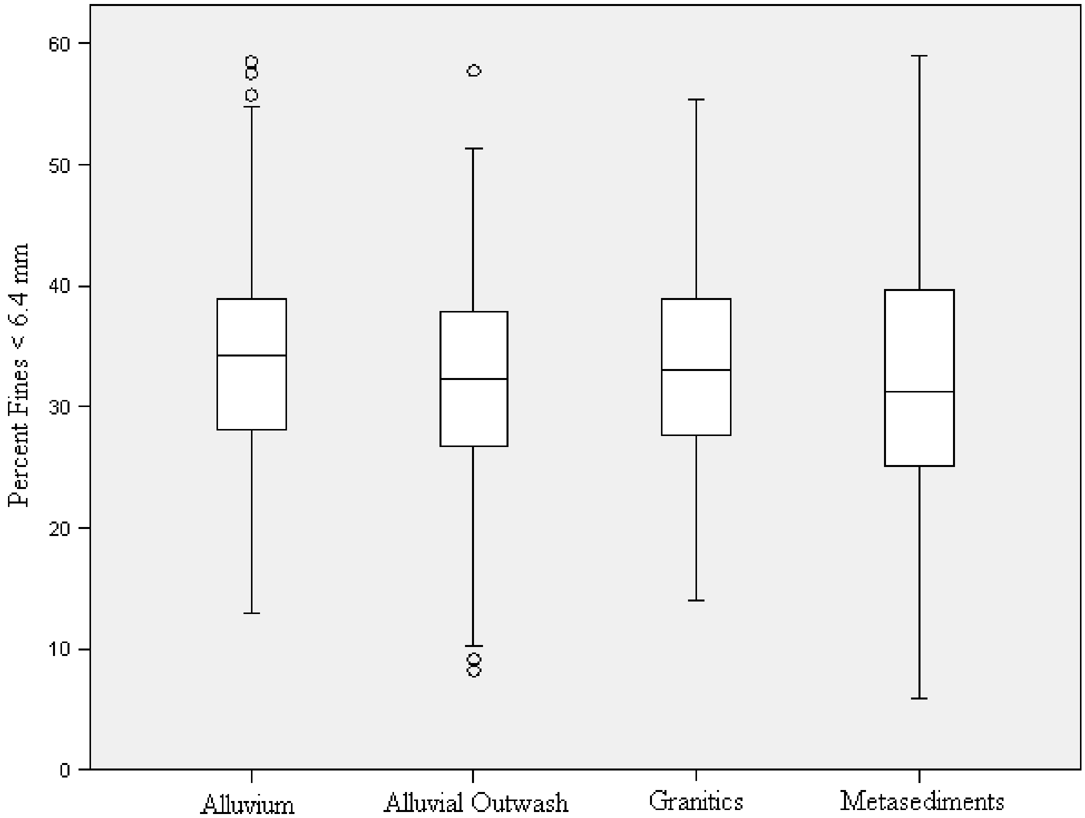

Figure 5-1. Percent fines <6.4 mm as represented by four major geomorphic groups of the Helena National Forest McNeil core dataset

The proposed McNeil core water quality indicators within spawning gravels are not to exceed 30% fines < 6.4 mm and no more than 10% < 0.85 mm. 30% fines < 6.4 mm reflects a value midway between the median and the 25th percentile of the Helena National Forest McNeil core dataset (**Table 5-4**). This indicator also reflects agreement with other sediment TMDLs approved by the state of Montana and the EPA: the Deep Creek and Upper Flathead TMDLs. The water quality indicator for percent fines < 0.85 mm is based on literature compiled by the state of Idaho for development of sediment TMDLs (Rowe et al., 2003 and Reylea 2000).

Table 5-4. Descriptive Statistics for the Helena National Forest McNeil Core Dataset

Mean	32.52
Standard Error	0.43
Median	32.33
25th Percentile	26.44
Mode	N/A
Standard Deviation	9.72
Sample Variance	94.47
Kurtosis	0.10
Skewness	0.09
Range	53.19
Minimum	5.87
Maximum	59.07
Count	514
95 % Confidence Level	0.84

Surface Fine Sediment

The percent of surface fines less than 6mm and 2mm is a measurement of the fine sediment on the surface of a stream bed. Increases in fine sediment have been linked to land management activities, and research has shown a statistically significant inverse relation between the amount of fine sediment <6.4 mm in spawning beds and successful salmonid fry emergence (Reiser and Bjornn 1979, Chapman and McLeod 1987, Weaver and Fraley 1991, McHenry et al. 1994, and Rowe et al. 2003). In addition, changes in macroinvertebrate communities have been shown to occur as fine sediments (<2 mm) increase above 20% coverage by area (Reylea et al. 2000). Thus, the amount of fine sediment on the streambed is directly linked to the support of the coldwater fishery and aquatic life beneficial uses.

During the 2005 stream channel assessments, surface fines data from the Upper Jefferson TPA was collected using a modified version of the Wolman pebble count technique. Data collected using this method tends to be highly variable, and the percent of fine sediment tends to be underestimated due to human bias. To reduce this variability, a total of three separate pebble counts were collected in each reach, with two pebble counts performed in riffles and one "composite" pebble count performed proportionally to the bed features present (e.g., pools and riffles). The modified composite pebble count was used for assigning a Rosgen stream classification and is the basis for the percent fines <6mm target. The other two pebble counts are the basis for assessing fine sediment levels present in riffles.

The water quality target for the percent of fine sediment on the streambed is based on departure of the percent of substrate <6mm beyond the reference range for the appropriate stream type based on the "composite" pebble count. Although the Beaverhead-Deerlodge National Forest Reference Dataset is based on the "zigzag" pebble count method, comparisons with 2005 Upper Jefferson reach composite pebble count datasets are reasonable. A second water quality target of ≤ 20% of the substrate <2mm in riffles will be used based on the requirements of aquatic macroinvertebrates (Bollman 2004, Reylea et. al. 2000). Departure from reference condition will apply when the reach average riffle pebble count value <2mm exceeds 20%. Fine sediment

targets shall not apply to low gradient E type streams with natural sand (E5) or silt (E6) substrates. Future surveys should document stable (if meeting criterion) or improving trends.

McNeil core samples were collected during the 2005 survey in trout spawning habitat (generally pool tail-outs) from select reaches of the Jefferson River (3 sites), Hells Canyon Creek (2 sites), Fish Creek (1 site), Big Pipestone Creek (1 site), and Whitetail Creek (headwaters also known as Little Whitetail Creek, 1 site). Six cores were collected from each survey reach to adequately represent spawning habitat conditions. Sampling protocols were based on Intermountain West spawning redd studies and reflect practices used by the Helena National Forest. The proposed McNeil core water quality indicators within spawning gravels are not to exceed 30% fines < 6.4 mm and no more than 10% < 0.85 mm. Future surveys should document stable (if meeting criterion) or improving trends.

Watershed geology has a strong influence on substrate size distribution. For example, granitic watersheds often exhibit a natural bimodal size distribution. Several of the tributaries of the Upper Jefferson Watershed listed as impaired due to sediment are located in watersheds with granitic geologies. Therefore, watershed geology will be considered when evaluating the relationship between management actions and the percent of surface fine sediment. This is particularly true in the case of the highly erosive granitic geology, the Boulder Batholith (TKb), that is found along some portion of all of the 303(d) listed tributary streams, except for Fitz Creek and Dry Boulder Creek.

Width/Depth Ratio and Entrenchment Ratio

The width/depth ratio and the entrenchment ratio are fundamental aspects of channel morphology. Each provides a measure of channel stability as well as an indication of the ability of a stream to transport and naturally sort sediment into a heterogeneous composition of fish habitat features (e.g., riffles, pools, and near-bank zones). Changes in both the width/depth ratio and entrenchment ratio can be used as indicators of change in the relative balance between the sediment load and the transport capacity of the stream channel. As the width/depth ratio increases, streams become wider and shallower, suggesting an excess coarse sediment load (MacDonald et al. 1991). As sediment accumulates, the depth of the stream channel decreases, which is compensated for by an increase in channel width as the stream attempts to regain a balance between sediment load and transport capacity. Conversely, a decrease in the entrenchment ratio signals a loss of access to the floodplain. Low entrenchment ratios signify that stream energy is concentrated in-channel during flood events versus having energy dissipation on the floodplain. Accelerated bank erosion and an increased sediment supply often accompany an increase in the width/depth ratio and/or a decrease in the entrenchment ratio (Knighton 1998, Rowe et al. 2003, Rosgen 1996).

The 75th percentiles of entrenchment ratios for C and E channels in the reference dataset range from 3.7 to 15.9 (**Table 5-3**). Although a higher entrenchment ratio is more desirable, if a channel is not entrenched, having an even higher ratio does not indicate a problem and is not a reasonable target. Rosgen and Silvey (1996) define a slightly entrenched C or E channel as having an entrenchment ratio greater than 2.2. Although this number is a generalization based on channel type data collected throughout the United States, and is not as applicable as regional reference data, it provides a frame of reference for an unentrenched channel. The smallest

reference entrenchment ratio for a C channel is 5.1; for an E channel 3.7. These numbers will be used as the entrenchment ratio target for C and E channels. A departure of the width/depth ratio and entrenchment ratio beyond the reference range for the appropriate stream type will be used as a water quality target for sediment impairments (**Table 5-3**).

Bank Erosion Hazard Index (BEHI)
Stream flows, sediment loads, riparian vegetation, and streambank material all influence bank stability, which, in turn, influences sediment contribution to the stream. The Bank Erosion Hazard Index (BEHI) is a composite metric of streambank characteristics that affect overall bank integrity and is determined based on bank height, bankfull height, rooting depth, bank angle, surface protection, and bank materials/composition (Rosgen 1996). Measurements for each metric are combined to produce an overall score or "rating" of bank erosion potential. Low BEHI values indicate a low potential for bank erosion. A bank erosion hazard index beyond the reference range for the appropriate stream type will be used as a supplemental indicator for sediment impairments.

The percent of eroding streambanks within a survey reach will be applied as a supplemental indicator for sediment impairments. Since streambank erosion is a natural process, this indicator will be used with caution. For example, just because eroding banks are present does not necessarily mean the erosion is human-induced or that there is an instream sediment problem. Additional information, such as observed bank trampling, removal of stabilizing vegetation, or increased water yield from timber harvest, will be considered. Departure from reference condition will apply when the percent of eroding banks within a survey reach exceeds 15% for A, B, C, and E type streams. These values are based on least impacted stream surveys in the Ruby Watershed, which, along with the Big Hole and Beaverhead rivers, is one of the three forks of the Jefferson River. Future surveys should document stable or improving trends.

5.4.1.2 Other Sediment Related Measures

Residual Pool Depths
Pools, like riffles, are important components of aquatic habitat. Excessive levels of sediment can lead to pool infilling and subsequent loss of habitat. Pools provide refuge for fish and are particularly crucial during summer low flows, when water temperatures are high, or in winter when low flows can cause freezing in some parts of the stream. Residual pool depth measurements quantify pool depth relative to the depth of the riffle crest. When performed over time, or compared with established reference conditions, this measure can be used to identify pool infilling and potential habitat loss. At this time, insufficient reference data are available to recommend specific water quality indicators for residual pool depths. Until appropriate reference conditions are identified, the 2005 inventory values will serve as benchmarks for future surveys, with the stipulation that future surveys document stable or improving trends.

Pool Frequency
Pool frequency varies based on the type of channel and the size of the stream. Pool-riffle channels (generally C, E, and some F types), step-pool channels (generally B type), and cascades (A type) are generally expected to have high pool frequencies (Montgomery and Buffington 1997). In general, a pool frequency of at least two pools for each meander wavelength would be

expected under natural conditions in meandering stream channels (C and E types), while step-pool channels (B types) would be expected to have more pools. At this time, insufficient reference data are available to recommend specific water quality indicators for pool frequency. Until appropriate reference conditions are identified, the 2005 inventory values will serve as benchmarks for future surveys with the stipulation that future surveys document stable or improving trends.

Large Woody Debris

Large woody debris plays a significant role in the creation of pools, especially in smaller stream channels. In a study conducted in northwestern Montana, Hauer et al. (1999) observed that single pieces of large woody debris situated perpendicular to the stream channel, or large woody debris aggregates, form the majority of pools. In the Middle and Lower Big Hole TPA riparian shrubs (e.g., willows, alders) were often responsible for pool formation, especially along valley streams. At this time, insufficient reference data are available to recommend specific water quality indicators for the amount of large woody debris. Until appropriate reference conditions are identified, the 2005 inventory values will serve as benchmarks for future surveys with the stipulation that future surveys document stable or improving trends.

Greenline Measurements

Interactions between the stream channel and streambank vegetation are vital components in the support of the beneficial uses of coldwater fish and aquatic life. Riparian vegetation provides food for aquatic organisms and supplies large woody debris that influences sediment storage and channel morphology. Vegetation can provide shading, cover, and habitat for fish. Vegetation holds streambank soils together, and the presence or lack of certain types of vegetation can significantly influence bank erosion rates. During assessments conducted in 2005, ground cover, understory vegetation, and overstory vegetation were cataloged at 10-foot intervals along the greenline at the bankfull channel margin along both sides of the stream channel for each survey reach. The percent of understory shrub cover is of particular interest in valley bottom streams historically dominated by willows and other riparian shrubs.

Based on the median understory shrub cover of 49% in reference reaches in the Upper Big Hole TPA, a supplemental indicator of ≥ 49% understory shrub cover is established for the Upper Jefferson TPA. The understory shrub cover will be applied in situations were riparian shrubs are a significant component of the streamside vegetation, such as in meadow areas. This supplemental indicator will not be applied in areas where dense conifer canopies and large substrate naturally limit the development of riparian shrubs.

Proper Functioning Conditions Assessments

The Proper Functioning Condition (PFC) method is a qualitative method for assessing the physical functioning of riparian-wetland areas (Prichard 1998). The hydrologic processes, riparian vegetation characteristics, and erosion/deposition capacities of streams were evaluated using the PFC method for each stream reach assessed in 2005. Each reach was rated as being in “proper functioning condition” (PFC), “functional – at risk” (FAR), or “non-functioning” (NF). Based on these assessments, a supplemental indicator of either “proper functioning condition” or “functional – at risk” with an upward trend with the intent of attaining “proper functioning condition” is established for the Upper Jefferson TPA.

Macroinvertebrates

Siltation exerts a direct influence on benthic macroinvertebrates assemblages through several mechanisms, including limiting the amount of preferred habitat for some taxa by filling in interstices, that is, spaces between gravel. In other cases, fine sediment limits attachment sites for taxa that affix to substrate particles. Macroinvertebrate assemblages respond predictably to siltation with a shift in natural or expected taxa to a prevalence of sediment-tolerant taxa over those that require clean gravel substrates. Macroinvertebrate bioassessment scores are an assessment of the macroinvertebrate assemblage at a site and are used by DEQ to evaluate impairment condition and beneficial use support. The advantage to these bioindicators is that they provide a measure of support of associated aquatic life, an established beneficial use of Montana's waters.

In 2006 DEQ adopted impairment thresholds for bioassessment scores based on two separate methodologies. The Multi-Metric Index (MMI) method assesses biologic integrity of a sample based on a battery of individual biometrics. The River Invertebrate Prediction and Classification System (RIVPACS) method uses a probabilistic model based on the taxa assemblage that would be expected at a similar reference site. Based on these tools, DEQ adopted bioassessment thresholds that reflected conditions that supported a diverse and biologically unimpaired macroinvertebrate assemblage and, therefore, a direct indication of beneficial use support for aquatic life.

The MMI is based on the different ecoregions within Montana. Three MMIs are used to represent the various Montana ecoregions: mountain, low valley, and plains. Each region has specific bioassessment threshold criteria that represent full support of macroinvertebrates. The Upper Jefferson watershed falls within both mountain and low valley regions. The MMI score is based upon the average of a variety of individual metric scores. The metric scores measure predictable attributes of benthic macroinvertebrate communities to make inferences regarding aquatic life condition when pollution or pollutants affect stream systems and instream biota. For the MMI, individual metric scores are averaged to obtain the final score, which ranges between 0 and 100. The impairment thresholds are 63 and 48 for the mountain and low valley indices, respectively. These values are established as supplemental indicators for sediment impairments in the Upper Jefferson TPA. The impairment threshold (10th percentile of the reference dataset) represents the point where DEQ believed macroinvertebrates were affected by some kind of impairment (e.g., loss of sensitive taxa).

The RIVPACS model compares the taxa that are expected at a site under a variety of environmental conditions with the actual taxa that were found when the site was sampled. The RIVPACS model provides a single dimensionless ratio to infer the health of the macroinvertebrate community. This ratio is referred to as the Observed/Expected (O/E) value. Used in combination, the results suggest strong evidence that a water body is either supporting or not supporting its aquatic life uses for invertebrates. The RIVPACS impairment threshold for all Montana streams is any O/E value <0.8. However, the RIVPACS model has a bidirectional response to nutrient impairment. Some stressors cause macroinvertebrate populations to decrease right away (e.g., metals contamination), which causes the score to decrease below the impairment threshold of 0.8. Nutrient enrichment may actually increase the macroinvertebrate

population diversity before eventually falling below 0.8. An upper limit was set to flag these situations. The 90th percentile of the reference dataset was selected (1.2) to account for these situations, and any value above this score is defined as impaired unless specific circumstances can justify otherwise. However, RIVPACS scores >1.0 are considered unimpaired for all other stressor types. A supplemental indicator value RIVPACS score of >0.80 and <1.2 is established for sediment impairments in the Upper Jefferson TPA. A score of greater than 1.2 does not necessarily indicate a problem, but, when combined with other data, may indicate nutrient or metal impacts.

Human-caused Sediment Sources
The presence of human-caused sediment sources does not always result in sediment impairment of a beneficial use. When there are no significant identified manmade sources of sediment within the watershed of a 303(d) listed steam, no TMDL will be prepared, since Montana's narrative criteria for sediment cannot be exceeded in the absence of human causes. Human-induced and natural sediment sources will be evaluated using recently collected data in comparison with the reference dataset, along with field observations and watershed scale source assessment information from aerial imagery and GIS data layers.

5.4.2 Existing Condition and Comparison to Water Quality Targets

This section includes existing data, a comparison of existing data with water quality targets and supplemental indicators, and a TMDL development determination for each 303(d) sediment listed water body in **Table 5-1**. All water bodies do not have data for all targets and supplemental indicators; all available relevant data are included in this section.

5.4.2.1 Big Pipestone Creek

Big Pipestone Creek was listed as impaired due to sedimentation/siltation on the 2006 303(d) List. In addition, this stream segment was listed for habitat alterations and other manmade substrate alterations that are forms of pollution commonly linked to sediment impairment. Big Pipestone Creek forms at the outlet of Delmoe Lake on the Beaverhead-Deerlodge National Forest and flows for approximately 20 miles to where it meets Whitetail Creek.

Physical Condition and Sediment Sources
The channel forms of Big Pipestone Creek above I-90 are predominantly controlled by landform structure, as well as reservoir releases from Delmoe Lake. The prominent landform geology, the Boulder Batholith, has resulted in valley bottom formation along weathered joints. Narrow valley bottoms dominated by granitic boulders (Rosgen B-type reaches) are found, as well as less confined valley bottom areas (Rosgen C-type reaches). Delmoe Lake releases have greatly increased the flow of the creek in this area. During the 2004 aerial assessment, various pollution sources observed in the upper portions of the watershed were related to the operation of Delmoe Lake Dam and from unpaved roads and trails (**Appendix C, Figure 2-7**).

A perched culvert on Big Pipestone Creek at the I-90 road crossing was viewed during an additional DEQ field survey in March 2006. When I-90 was built, the valley created by Big Pipestone Creek was filled with boulders and a large culvert was installed through the ballast.

However, the culvert was installed approximately 20 feet above the streambed and is functional only during extreme runoff events. Under normal conditions all of the water in Big Pipestone Creek drains through the subsurface boulder fills under I-90 to continue on course. The culvert appears to act as a trap for many of the fine sediments transported by the creek, as indicated by a large depositional zone extending well above the culvert (north side of I-90). It is possible that this trap prevents many fine sediments from being transported to the valley bottom segment of the creek and affects the sediment transport capacity of the creek below the culvert. Should the culvert be brought to the proper grade for surface flow, more fine sediments could be transported to and deposited within the valley reaches.

Below I-90 the channel forms within Big Pipestone Creek are controlled by historical and current land use activities. As noted in the 2004 aerial assessment, the predominant valley type (VIII) in this area would typically result in an unconfined Rosgen stream type (C or E). Yet water level alterations for flow diversions, as well as channelization, have resulted in stream types out of balance with the valley type. In some instances, during the aerial assessment, Rosgen stream type could not be discerned due to the presence of a constructed versus a natural alluvial channel. In addition, extreme headcutting was noted in the lowermost reach of the watershed and more than likely cause or contributed to the observed channelization. During the 2004 assessment numerous pollution sources observed along Big Pipestone Creek below I-90 were related to agriculture. During the field source assessment, grazing impacts (trampled banks, overwidened channel, channel braids) and stream channel alterations were observed in most of the reaches. In general, stream condition deteriorated heading downstream (**Appendix C, Figure 2-8**).

In September 1994 DEQ performed a stream reach assessment at an upper and lower site within the Big Pipestone Creek drainage. Qualitative data collected suggested moderate habitat impairments to instream and riparian health. Identified sources of sediment include mining, unpaved roads, and riparian grazing. Other information taken from DEQ’s files include historic assessments that identified the effects of irrigation infrastructure and hydromodification on instream sediment production and channel modifications, particularly extensive headcutting in the lower portions of the watershed.

In 2005 DEQ performed two focused assessments in the upper portions of the watershed above I-90. These survey sites were located 5 (BIGP5) and 11 (BIGP12) miles below the Delmoe Lake outlet. The lowermost 2005 survey site on Big Pipestone Creek (BIGP15) was located about 18 miles below the Delmoe Lake outlet (DEQ 2006)

In addition to the 2005 inventory, two channel surveys were conducted by the Beaverhead-Deerlodge National Forest on upper Big Pipestone Creek (above the I-90 crossing), which corresponds with portions of Reaches 1 (BIGP1-FS01) and 5 (BIGP5-FS99) delineated during the 2004 source assessment. BIGP1-FS01, inventoried in 2001, is located approximately one-half-mile below the Delmoe Lake outlet. BIGP5-FS99, inventoried in 1999, is the same site that was inventoried in 2005, BIGP5 (DEQ 2006).

Comparison to Water Quality Targets
The existing data in comparison with the targets and supplemental indicators for Big Pipestone Creek are summarized in **Tables 5-5, 5-6,** and **5-7**.

Table 5-5. Big Pipestone Creek Sediment Data Compared with Targets*

Reach ID	Pebble Count		McNeil Core		Cross Section		Rosgen Level II**	
	Composite % < 6mm (mean)	**Riffle %<2mm (mean)**	**% <0.85 mm**	**% <6.4 mm**	**Width / Depth Ratio (median)**	**Entrenchment Ratio (median)**	**E**	**P**
BIGP1-FS01	8%	NA***	NA	NA	11.3	**1.4********	F4	B4
BIGP5-FS99	75%	NA	NA	NA	9.7	**1.7********	B5c	C5
BIGP5	**40%**	15%	**17%**	**39%**	15.8	**1.6**	B4	B4
BIGP12	**51%**	**38%**	NA	NA	**10.8**	**3.0**	C4	E4
BIGP15	**89%**	**49%**	NA	NA	12.0	9.7	C5	C4

***Bolded** values represent departure from water targets based on Rosgen Level II potential.
** E = Existing Stream Type & P = Potential Stream Type.
***NA = data not available
**** Forest Service Data based upon a single measure of entrenchment.

Table 5-6. Big Pipestone Creek Sediment Data Compared to Supplemental Indicators.

Reach ID	BEHI Score (mean)	BEHI Adjective Rating	% Non-Eroding Banks	P.F. Condition	Residual Pool Depth (mean)	Pool Frequency (#/mile)	Large Woody Debris Frequency (#/mile)
BIGP1-FS01	NA	NA	NA	**NF**	NA	NA	NA
BIGP5-FS99	NA	NA	NA	FAR	NA	NA	NA
BIGP5	**33.3**	**High**	97.6	FAR	0.95	88	300
BIGP12	**38.8**	**High**	85.9	FAR	0.6	70	23
BIGP15	**32.7**	**High**	**56.4**	FAR	1.23	105	100

***Bolded** values represent departure from the water quality indicators.

Table 5-7. 2005 Greenline Survey data for Big Pipestone Creek.

Ground Cover	**BIGP5**	**BIGP12**	**BIGP15**
Rock/Root	34%	23%	5%
Riprap	0	2%	0
Bare Ground	6%	17%	10%
Herbaceous	53%	46%	79%
Wetland	8%	13%	7%
Understory	**BIGP5**	**BIGP12**	**BIGP15**
Deciduous	77%	**46%**	**41%**
Coniferous	0	0	0
Mixed	6%	0	0
Overstory	**BIGP5**	**BIGP12**	**BIGP15**
Deciduous	0	0	12%
Coniferous	13%	0	0
Mixed	0	0	0

***Bolded** values represent departure from the water quality indicators.

For the survey sites along Big Pipestone Creek above I-90, the composite surface fines value <6 mm at BIGP5 was 60% greater than the defined reference mean for B4 streams, and the values for both classes of percent fines in McNeil core samples were elevated against the target values. The percentage of subsurface fines <6.4 mm at BIGP5 was 29% greater than the defined reference mean, while the percentage of fine fines (<0.85 mm) was 70% greater. The 2005 McNeil core data have computed a reach averaged geometric mean subsurface particle size equivalent to fine gravels (6.8 mm). Measures of subsurface sediment include more fine particles than a surface sediment evaluation (pebble count). The entrenchment ratio values for BIGP1-FS01, BIGP5-FS99, and BIGP5 were believed to have been different from reference due to hydromodification associated with Delmoe Lake operations, suggesting that access to the floodplain has been reduced. At both sites the 2005 Proper Functioning Condition assessment rated the reaches as functional at risk (FAR), with no apparent trend. Negative ratings were mostly due to channel form and riparian alterations believed to be caused by flow withdrawals and grazing practices. Human-caused bank erosion was observed at both these sites and was primarily influenced by riparian grazing and irrigation shifts in stream energy directly related to dam operations. Under the assumption that Delmoe Lake operations were following reasonable land, soil, and water conservation practices, the entrenchment ratio values and PFC ratings will not be considered a violation of proposed reference conditions.

For the survey sites along Big Pipestone Creek below I-90 (BIGP12 and BIGP15), the water quality indicator values for surface sediments were not within reference. The percentage of surface fines <2 mm at BIGP12 was 89% greater than the defined reference mean, while the percentage of composite surface fines <6 mm was anywhere from 34% (E4) to 76% (C4) greater, depending on Rosgen stream type. At BIGP15, the percentage of surface fines <2 mm was 147% greater than the defined reference mean, while the percentage of surface fines <6 mm was 208% (C4) greater. The entrenchment ratios were 81% (E4) lower than expected, suggesting that access to the floodplain has been reduced. In this location excess fine sediment was noted and the Proper Functioning Condition assessment rated the reach as functional at risk (FAR), with no

apparent trend. Negative ratings were mostly due to channel form and riparian alterations believed to be caused by flow modifications, upstream channelization, cropping (past), and grazing practices. This is further supported by the exceedences of the understory riparian vegetation supplemental indicator at BIG12 and BIG15. Human-influenced bank erosion was observed and primarily influenced by riparian grazing and cropping. The Properly Functioning Conditions (PFC) ratings were not considered exceedences of the proposed reference conditions, given that trends were not discernable.

Streambank erosion in all reaches did not meet the supplemental indicator value for bank erosion. However, the percent of reach with non-eroding banks was meeting the supplemental indicator value of ≥ 85% in the uppermost two monitoring sections, though it was below the criteria in the lower monitoring section, with a value of 56%.

Summary and TMDL Development Determination
Based on the data reviewed for Big Pipestone Creek, instream habitats for aquatic life and coldwater fisheries beneficial uses are likely impacted and affected by sediment. In the upper portion of the watershed, fine surface and subsurface sediments are accumulating in macroinvertebrate and fish spawning habitats. Land disturbance appears to exacerbate erosion in the Boulder Batholith geology and the poorly developed soils of this subwatershed. The exceedence of the fines reference value (<0.85 mm) supports this conclusion.

In the Jefferson valley reaches of Big Pipestone Creek fine surface sediments appear to be accumulating in riffles, and pool habitat is also likely affected. As noted during the 2005 field assessment and in historic data, hydromodification related to irrigation withdrawals is likely affecting sediment transport and channel morphology. In addition, the 2004 source assessment reveals that additional active human-induced sediment sources are present.

Elevated surface fines in riffles can harm aquatic insects, while high fines in spawning gravels can disrupt and even prevent trout reproduction. Limited pool habitat may also be of concern for some reaches of the creek. Lower than expected entrenchment ratios could equate to increased sediment loading from streambanks. Bank erosion did appear to be problematic in the Jefferson valley survey reaches of Big Pipestone Creek. During the 2005 inventory many sediment sources were present, such as road/trail inputs, riparian grazing, and severe channel modifications (channelization/headcutting) that were related to human activities.

These results indicate an increased sediment supply and a decreased capacity to transport sediment, particularly in the lower part of Big Pipestone Creek. Available sediment and habitat data suggest that fine sediment deposition within Big Pipestone Creek is likely impacting fish spawning and rearing habitat and the aquatic macroinvertebrate assemblages that support the fishery. The primary human-caused sources of sediment within the watershed include rangeland and near-stream grazing, bank erosion, and unpaved and paved roads. This information supports the 303(d) listing, and a sediment TMDL will be completed for Big Pipestone Creek.

5.4.2.2 Cherry Creek

Cherry Creek was listed as impaired due to sedimentation/siltation on the 2006 303(d) List. In addition, this stream segment was listed for habitat alterations, which is a form of pollution commonly linked to sediment impairment. Cherry Creek originates at Little Cherry Creek Spring on the Beaverhead-Deerlodge National Forest. It flows for approximately 7 miles to where it meets the Jefferson River. During the summer irrigation season, landowners reported that the stream goes dry on the lower alluvial fan before reaching the Jefferson River.

Physical Condition and Sediment Sources
Cherry Creek's channel forms are primarily controlled by landform structure. The prominent geology, the Boulder Batholith, has resulted in valley bottom formation along weathered joints. The stream headwaters occur on relatively steep slopes (A-type), moving toward more moderate slopes downstream. The valley bottom is fairly confined (B-type reaches) until exiting the canyon to the alluvial fan (B and Eb reaches) (**Appendix C, Figure 2-13**). Within Cherry Creek many of the pollution sources observed during the 2004 aerial review and field assessments were related to riparian grazing and unpaved roads. In the upper reaches of the creek, the source of flow alterations from water diversions was taken from a GIS layer that located water rights claims. In addition, some impacts from abandoned mine lands were noted. Silviculture activities were also noted in the headwaters. Grazing impacts observed in the field were more detrimental in lower portions of the watershed. Sediment input from unpaved roads was fairly minimal. Loss of riparian habitat was associated with development in the floodplain (roads, crops, housing).

In 2003 DEQ conducted water quality assessments at two locations within the watershed, using DEQ reassessment protocols. The upper site (DEQ Upper) was located approximately 6.5 miles from the mouth, and the lower site (DEQ Lower) was located about 1 mile upstream of Montana Highway 41. This assessment provided the majority of data used for updates to the water body's listing status in 2006. In addition to the 2003 DEQ data, in 2005 DEQ performed a sediment and stream morphology assessment at one location within the Cherry Creek watershed. This site (CHRY6) was located about 6 miles below the headwaters (DEQ 2006).

Biological Data
In 2003 DEQ collected macroinvertebrate samples at two sites on Cherry Creek. The bioassessment scores are presented in **Table 5-11**.

Comparison with Water Quality Targets
Comparisons of existing data with the targets and supplemental indicators for Big Pipestone Creek are summarized in **Tables 5-8, 5-9, 5-10,** and **5-11**.

Table 5-8. Cherry Creek Sediment Data Compared to Targets*.

Reach ID	Pebble Count		McNeil Core		Cross Section		Rosgen Level II**	
	Composite % < 6mm (mean)	Riffle % <2mm (mean)	% <0.85 mm	% <6.4 mm	Width / Depth Ratio (median)	Entrenchment Ratio (median)	E	P
DEQ Upper	**43%**	**41%**	NA***	NA	NA	NA	NA	B4
DEQ Lower	77%	**69%**	NA	NA	NA	NA	NA	B5
CHRY6	62%	28%	NA	NA	**4.4**	3.8	E5b /B5	E5b/ B5

***Bolded** values represent departure from water targets based on Rosgen Level II potential.
** E = Existing Stream Type & P = Potential Stream Type.
***NA = data not available

Table 5-9. Cherry Creek Sediment Data Compared with Supplemental Indicators

Reach ID	BEHI Score (mean)	BEHI Adjective Rating	% Non-Eroding Banks	P.F. Condition	Residual Pool Depth (mean)	Pool Frequency (#/mile)	Large Woody Debris Frequency (#/mile)
CHRY6	**30.9**	**High**	96.9	FAR	0.54	129	6

***Bolded** values represent departure from the water quality indicators.

Table 5-10. 2005 Greenline Survey Data for Cherry Creek

Ground Cover	**CHRY6**
Rock/Root	18%
Riprap	2%
Bare Ground	32%
Herbaceous	48%
Wetland	2%
Understory	**CHRY6**
Deciduous	61%
Coniferous	0
Mixed	1%
Overstory	**CHRY6**
Deciduous	1%
Coniferous	0
Mixed	0

Table 5-11. Biological Metrics for Cherry Creek
Bolded text failed to meet the target (Mountain MMI ≥ 63, Low Valley ≥ 48, and RIVPAC ≥ 0.80)

Station ID	Date	Class	Mountain Index	RIVPACS O/E
M08CHRYC01	10/12/2003	Mountains	84	1.17
M08CHRYC02	10/12/2003	Low Valley	55	0.89

Many of the selected sediment water quality indicator values were not within reference for the survey sites on Cherry Creek. Surface fine sediment targets of <2mm and <6mm were not met at both the 2003 DEQ Upper and DEQ Lower sites. Information taken from the DEQ files regarding the lower assessment site stated:

> The channel is actively downcutting. About 40 percent of streambanks show signs of lateral cutting. Sediment load is high; Cattle and sheep (including an on-channel confined feeding operation) and roads contribute to the elevated sediment load. (Maps and 1995 orthophotos indicate that most roads are situated in adjoining drainages, and that this drainage is only lightly-roaded, mostly in the lower reaches.) Early-seral woody species are reduced by livestock (cattle and sheep) browsing. Irrigation diversions are present, and reduce flow volume. PFC rating is "Functioning At Risk." MT DEQ supplement questions: Habitat types are reduced, little structure present. Spawning extensively reduces due to deposition and storage of fines in the substrate. The stream is a losing reach and the channel is dewatered for hay field irrigation (dry channel below this site). No structures are present to prevent fish entrainment to the numerous irrigation ditches. The overall rating is "At Risk" (DEQ Waterbody Assessment Files).

At the 2005 site no percent fines reference values were applied to the E5 stream type. However, the W/D slightly exceeded reference condition in comparison with the 75th percentile of reference E5 stream types. Again, both the E5 and B5 stream types have naturally elevated percent fines. The 2005 Proper Functioning Condition assessment rated the assessment reach as functional at risk (FAR), with an upward trend, given channel and riparian area recovery from historic land use. Negative ratings were mostly due to riparian and channel alterations stemming from historic land use (orchard operation) and riparian grazing.

At the 2005 inventory site, 3% of the survey reach was measured as having actively eroding banks. BEHI metrics for the eroding banks were rated as having moderate to high potentials for erosion. An overall BEHI rating for the reach was judged to be moderate. Sources contributing to the total reach calculated sediment load from bank erosion were historic land use (orchard operations), riparian grazing, and natural sources. That being said, the percent of non-eroding streambanks supplemental target was not exceeded at 97%.

Macroinvertebrate data collected in October 2003 met select supplemental targets for the mountain (>63) and valley (>48) MMI scores. The RIVPACS values met selected target levels; however, the lowermost site was near the target value.

Summary and TMDL Development Determination
Based on the data reviewed for Cherry Creek, instream habitats for aquatic life and coldwater fisheries beneficial uses may be negatively affected by sediment. Fine surface sediments are accumulating in riffles and, potentially, pool habitat is also being affected. Elevated surface fines in riffles can harm aquatic insects. A W/D above the expected values would also support a conclusion of sediment impairment. However, the strength of this target alone in these stream types does not provide overwhelming justification.

In addition to the target comparison information above, significant sediment sources related to current and historic human activities are present, such as riparian grazing and channel modifications (historic land use, rip rap, etc.). DEQ's Waterbody Assessment files reported that the streambanks were visually eroding. The main cause of the sediment problem seemed to be caused livestock trampling.

In addition, sediment source assessment results, presented in **Section 5.5**, document significant controllable human-derived sediment source contributions from unpaved roads, streambanks, and other upland sediment sources.

Available sediment and habitat data suggest that fine sediment deposition within Cherry Creek is likely impacting fish spawning and rearing habitat and the aquatic macroinvertebrate assemblages that support the fishery. In addition, there are significant controllable human-caused sources. The primary human sources of sediment within the watershed include rangeland and near-stream grazing and bank erosion. This information supports the 303(d) listing, and a sediment TMDL will be completed for Cherry Creek.

5.4.2.3 Fish Creek

Fish Creek was listed as impaired due to sedimentation/siltation on the 2006 303(d) List. This stream segment was listed for alteration in stream-side or littoral vegetative covers, which are forms of pollution commonly linked to sediment impairment. Fish Creek originates in the Highland Mountains on the Beaverhead-Deerlodge National Forest. It flows for approximately 20 miles to where it meets the Jefferson Canal, one of the major irrigation canals in the Jefferson valley. Due to irrigation water withdrawals and natural losses to the alluvial fan, the creek goes dry for much of the year before reaching the Jefferson Canal.

Physical Condition and Sediment Sources
The channel forms of Fish Creek within the Highland Mountains are predominantly controlled by landform structure, as well as historical land uses (**Appendix C, Figure 2-19**). The upper reaches have been affected by faulting and glaciation, and more recently by placer mining and logging activities. Before entering the Jefferson valley, the Boulder Batholith geology has weathered into narrow valley bottom sections (B-type reaches), as well as less confined valley bottom areas (C-type reaches). During the 2004 aerial photo review and associated field surveys, many pollution sources observed along upper Fish Creek were related to placer mining, riparian grazing, and unpaved roads. In many instances the sources of flow alterations from water diversions and impacts from abandoned mines were taken from GIS layers that located water rights claims and abandoned mines. The GIS-identified sources have generally not been field

verified. Tree harvesting before 1983 have occurred upslope from and adjacent to Fish Creek. Harmful effects from this impact were not observed in the field (DEQ 2005).

Many of the channel forms of Fish Creek in the Jefferson Valley are controlled by landform structure and historical and current land use activities (**Appendix C, Figure 2-20**). Channel form on the alluvial fan tended to be more unconfined than expected (C-type versus B-type). Fish Creek typically goes dry before entering Fish Creek Canal. The area near the canal was not classified due to the fact that it is part of a major irrigation canal system in the Jefferson valley and probably carries flow from the Jefferson River rather than Fish Creek. Many pollution sources observed on the aerial photographs during the 2004 assessment for lower Fish Creek were related to agricultural operations (irrigation diversions, cropping, and loss of riparian area). During the field source assessment, active beaver dams were observed. Discussions with local landowners revealed that dewatering of the creek results in isolation of a genetically pure Westslope cutthroat trout population, which apparently thrives in the reaches above the alluvial fan.

In 2003 DEQ conducted water quality assessments at two locations within the watershed (DEQ Upper and DEQ Lower), using DEQ reassessment protocols. This assessment provided the majority of data used for updates to the water body's listing status in 2006. In 2005 DEQ performed a focused sediment and stream morphology assessment at three locations within the Fish Creek watershed. These sites were located approximately 3.5 (FISH5), 6 (FISH8), and 14 (FISH14) miles below the headwaters (DEQ 2006). In addition to the 2005 inventory, one channel survey was completed by the Beaverhead-Deerlodge National Forest in 2001 (FISH6-FS-01). This site was located approximately 4.5 miles from the headwaters. At this location a shift in Rosgen stream type from E4 to B4 was noted and attributed to grazing, roads, and placer mining. (DEQ 2006).

Biological Data
In 2003 DEQ collected macroinvertebrate samples at two sites on Fish Creek. The bioassessment scores are presented in **Table 5-15**.

Comparison to Water Quality Targets
The existing data in comparison with the targets and supplemental indicators for Fish Creek are summarized in **Tables 5-12, 5-13, 5-14,** and **5-15**.

Table 5-12. Fish Creek Sediment Data Compared to Targets*.

Reach ID	Pebble Count		McNeil Core		Cross Section		Rosgen Level II**	
	Composite % < 6mm (mean)	Riffle %<2mm (mean)	% <0.85 mm	% <6.4 mm	Width / Depth Ratio (median)	Entrenchment Ratio (median)	E	P
DEQ Upper	**36%**	**22%**	NA	NA	NA	NA		B4/C4
DEQ Lower	**73%**	**73%**	NA	NA	NA	NA		B4/C4
FISH5	5%	3%	NA	NA	12.8	**1.4**	B3	B3
FISH6-FS01	14%	NA	NA	NA	**15.9**	**1.8*****	B4	E4
FISH8	13%	12%	9%	**31%**	17.2	**4.3**	C4b	C4b
FISH14	18%	5%	NA	NA	12.9	**1.5**	B4c	C4

***Bolded** values represent departure from water targets based on Rosgen Level II potential.
** E = Existing Stream Type & P = Potential Stream Type.
***NA = data not available
**** Forest Service Data based upon a single measure of entrenchment.

Table 5-13. Fish Creek Sediment Data Compared to Supplemental Indicators.

Reach ID	BEHI Score (mean)	BEHI Adjective Rating	% Non-Eroding Banks	P.F. Condition	Residual Pool Depth (mean)	Pool Frequency (#/mile)	Large Woody Debris Frequency (#/mile)
FISH5	**31.6**	**High**	98.6	PFC	0.59	100	65
FISH6- FS01	NA	NA	NA	**NF**	NA	NA	NA
FISH8	0	Very Low	0	PFC	0.94	100	65
FISH14	**32.4**	**High**	90.2	FAR	1.15	76	100

***Bolded** values represent departure from the water quality indicators.

Table 5-14. 2005 Greenline Survey Data for Fish Creek

Ground Cover	**FISH5**	**FISH8**	**FISH14**
Rock/Root	NA	NA	39%
Riprap	0	0	0
Bare Ground	13%	8%	7%
Herbaceous	23%	89%	56%
Wetland	65%	3%	0
Understory	**FISH5**	**FISH8**	**FISH14**
Deciduous	13%	18%	73%
Coniferous	19%	7%	1%
Mixed	5%	1%	1%
Overstory	**FISH5**	**FISH8**	**FISH14**
Deciduous	0	0	0
Coniferous	41%	44%	0
Mixed	0	0	39%

Table 5-15. Biological Metrics for Fish Creek
Bolded text failed to meet the target (Mountain MMI ≥ 63, Low Valley ≥ 48, and RIVPAC ≥ 0.80)

Station ID	**Date**	**Class**	**Mountain Index**	**RIVPACS O/E**
M08FISHC01	10/13/2003	Mountains	80	0.96
M08FISHC02	10/13/2003	Low Valley	71	0.88

The 2003 reassessment of Fish Creek (DEQ Upper and DEQ Lower) showed riffle substrate percent fines smaller than 6 mm, increased from 36% at the Upper site and 73% at the Lower site. Also, the percentage of fine particles smaller than 2 mm increased from 22% at the Upper site to 73% at the Lower site. Rosgen stream type was not estimated. However, assuming either a B4 or C4 stream type typical of this area, percent fines <6 mm and <2 mm both exceed the target value**.** Other qualitative information associated with this sampling event noted excess sediment production from trampled banks and human activities exacerbating the highly erosive geology.

The assessment data collected in 2005 by DEQ revealed that most of the selected sediment water quality targets and indicator values were judged to be within reference for the survey sites along Fish Creek. However, the entrenchment ratios differed from reference for all the survey sites, suggesting that access to the floodplain has been reduced and the potential for bank erosion has increased. The shift in Rosgen stream type from E4 to B4 that was documented at FISH6- FS01 supports the conclusion that surface fines may be a problem due to the increased entrenchment. With a potential Rosgen stream type of E4, the W/D at FISH6- FS01 was greater than reference, while the entrenchment ratio was less. The 2001 PFC rating for this section of Fish Creek was also considered different from proposed reference conditions. At FISH8, the values for the percent fines <6.4mm in McNeil core samples were slightly elevated (3%) against the target value, while the percentage of fines (<0.85 mm) was 7% less. Additionally, the 2005 BEHI survey at FISH5 and FISH14 indicates that bank erosion was greater than expected for reference

and primarily attributable to human sources. That being said, the total percent of non-eroding banks per site was greater then the selected target value of 85%.

Macroinvertebrate data collected in October 2003 met select supplemental targets for the mountain (>63) and valley (>48) MMI scores, as well as supplemental RIVPACS values.

Summary and TMDL Development Determination
Based on the data reviewed for Fish Creek, instream habitats for aquatic life and coldwater fisheries beneficial uses are likely impacted and affected by sediment. Elevated fines in riffles are apparent in the 2003 assessment data and may be affecting instream macroinvertebrate habitat. Fine surface sediments are accumulating in riffles and, potentially, pool habitat is also being affected. Greater than expected W/D and lower than expected entrenchment ratios could equate to increased sediment loading from streambanks. Bank erosion did appear to be a problem at two of the four inventory sites. In addition, significant controllable human-derived sediment source contributions from unpaved roads, streambanks, and other upland sediment sources are documented. This information supports the 303(d) listing, and a sediment TMDL will be completed for Fish Creek.

5.4.2.4. Fitz Creek

Fitz Creek was listed as impaired due to sedimentation/siltation on the 2006 303(d) List. This stream segment was listed for alteration in stream-side or littoral vegetative covers, which are forms of pollution commonly linked to sediment impairment. Fitz Creek forms in the Bull Mountains on the Beaverhead-Deerlodge National Forest. It flows for approximately 5 miles to where it meets Little Whitetail Creek. For much of the year the creek goes dry on the alluvial fan before reaching Whitetail Creek.

Physical Condition and Sediment Sources
The channel forms of Fitz Creek are primarily controlled by landform structures. The stream headwaters occur on relatively steep slopes (A-type), moving toward more moderate slopes downstream. The valley bottom is fairly confined (B-type reaches) along the canyon and alluvial fan sections until entering the floodplain of Little Whitetail Creek (**Appendix C, Figure 2-25**). Most of the pollution sources observed on the aerial photos were related to flow alterations and unpaved roads. In many instances, the source of flow alterations from water diversions was taken from a GIS layer and was not field verified. Grazing was observed along much of the lower reaches of the stream, but the impacts were fairly minimal due to the lack of water. During the 2004 field source assessment the stream was observed as naturally going dry at the head of the alluvial fan. On the alluvial fan the stream goes distributary and probably does not carry flow, except during spring runoff and intense rainfall events. These characteristics are typical for streams on alluvial fans in arid environments.

In 2003 DEQ conducted a water quality assessment at one location within the watershed approximately 1.5 miles upstream from the mouth. This assessment provided the majority of data used for updates to the water body’s listing status in 2006. Qualitative data showed significant grazing impacts, and photos show areas of compacted soils, barren of vegetation adjacent to the

channel, with a narrow band of grass along the streambanks. The channel and riparian is hoof-pugged (DEQ Waterbody Assessment Files).

In 2005 DEQ performed a sediment and stream morphology assessment at one location within the Fitz Creek watershed. This site (FITZ4) was located about 2.8 miles below the headwaters (DEQ, 2006)

Comparison with Water Quality Targets
The existing data in comparison with the targets and supplemental indicators for Big Pipestone Creek are summarized in **Tables 5-16, 5-17** and **5-18**.

Table 5-16. Fitz Creek Sediment Data Compared with Targets*

Reach ID	**Pebble Count**		**McNeil Core**		**Cross Section**		**Rosgen Level II****	
	Composite % < 6mm (mean)	**Riffle % <2mm (mean)**	**% <0.85 mm**	**% <6.4 mm**	**Width / Depth Ratio (median)**	**Entrenchment Ratio (median)**	**E**	**P**
FITZ4	23%	19%	NA	NA	**8.0**	**1.7**	E4a/ B4a	E4a/ B4a

***Bolded** values represent departure from water targets based on Rosgen Level II potential.
** E = Existing Stream Type & P = Potential Stream Type.
***NA = data not available

Table 5-17. Fitz Creek Sediment Data Compared with Supplemental Indicators

Reach ID	BEHI Score (mean)	BEHI Adjective Rating	% Non-Eroding Banks	P.F. Condition	Residual Pool Depth (mean)	Pool Frequency (#/mile)	Large Woody Debris Frequency (#/mile)
FITZ4	**36.1**	**High**	99.7	FAR	0.33	65	47

***Bolded** values represent departure from the water quality indicators for potential Rosgen stream type.

Table 5-18. 2005 Greenline Survey Data for Fitz Creek

Ground Cover	**FITZ4**
Rock/Root	43%
Riprap	
Bare Ground	1%
Herbaceous	57%
Wetland	
Understory	**FITZ4**
Deciduous	52%
Coniferous	2%
Mixed	4%
Overstory	**FITZ4**
Deciduous	14%
Coniferous	43%
Mixed	

Most indicator values were judged to be within reference for the survey site on Fitz Creek. However, the water quality indicator values for W/D and entrenchment ratio may have exceeded reference condition by 14% and 80%, respectively, in comparison with the 75th percentile of reference EA stream types.

The bank erosion hazard index at this site did not meet reference condition, with an average condition rated as high. However, the total percent of non-eroding banks met the supplemental indicator criteria of > 85%. The 2005 inventory measured < 1% of the total survey length as having eroding banks.

Other relevant information taken from DEQ's Waterbody Assessment files includes data generated from the 2003 reassessment of Fitz Creek. The 2003 information suggests that human sources of sediment are present:

> The stream is of small scale and is a losing reach below the sampling site. The riparian is not functioning here as a result of heavy livestock impacts. Willows and sedges are removed by livestock, and the soils adjacent to the narrow riparian are trampled, compacted, and mostly devoid of vegetation. The expected willow/sedge community has converted to grass and some forbs as a consequence of livestock grazing. Field photos indicate that fine particles comprise a significant portion of the channel substrate. As thoroughly trampled as this channel appears, it is reasonable to think that the supply and storage of fine sediment is elevated (DEQ Waterbody Assessment Files).

Summary and TMDL Development Determination

Available sediment and habitat data suggest that fine sediment deposition within Fitz Creek could be potentially impairing the coldwater fishery and aquatic life beneficial uses. However, more data is necessary to adequately determine if instream habitats for aquatic life and coldwater fisheries beneficial uses are negatively affected by sediment. No sediment TMDL will be prepared for Fitz at this time, and additional monitoring is recommended to evaluate the extent of

naturally occurring fine sediment, the significance of human sources, and impacts to beneficial uses.

5.4.2.5. Halfway Creek

Halfway Creek was listed as impaired due to sedimentation/siltation on the 2006 303(d) List. This stream segment was listed for alteration in stream-side or littoral vegetative covers, which are forms of pollution commonly linked to sediment impairment. Halfway Creek forms in Halfway Park on the Beaverhead-Deerlodge National Forest. It flows for approximately 8 miles to where it meets Big Pipestone Creek.

Physical Condition and Sediment Sources
The channel forms of Halfway Creek are predominantly controlled by landform structure. Halfway Park, the headwater area, is a broad wetland meadow with fairly gentle slopes. Channel form here is thought to be E-type. Once the stream leaves Halfway Park, the gradient steepens (A-type) and flow is confined to the canyon. Below the canyon the Boulder Batholith geology has weathered into less confined valley bottom sections (Ea and Eb-type reaches), as well as narrow valley bottom areas (B-type reaches) (**Appendix C, Figure 2-28**). The 2004 aerial assessment documented various sediment sources, including water diversions and impacts from abandoned mines and the loss of riparian habitat associated with road development and grazing. Many pollution sources observed along Halfway Creek were related to riparian grazing and unpaved roads and trails (overwidened channel, bank erosion, loss of vegetation). During the field source assessment, the channel condition appeared to degrade heading downstream.

In 2003 DEQ conducted a water quality assessment at one location within the watershed (DEQ-03) using DEQ reassessment protocols. This assessment provided the majority of data used for updates to the water body’s listing status in 2006. In 2005 DEQ performed a sediment and stream morphology assessment at one location within the Halfway Creek watershed. The site (HWFY7) was located about 5 miles below the headwaters. In addition to the DEQ inventories, two channel surveys were completed by the Beaverhead-Deerlodge National Forest (HFWY1-FS01 and HFWY7-FS01). This information is provided below. (DEQ, 2006).

Biological Data
In 2003 DEQ collected macroinvertebrate samples at one site on Halfway Creek. The bioassessment scores are presented in **Table 5-22**.

Comparison with Water Quality Targets
The existing data in comparison with the targets and supplemental indicators for Halfway Creek are summarized in **Tables 5-19, 5-20, 5-21,** and **5-22**.

Table 5-19. Halfway Creek Sediment Data Compared to Targets*

Reach ID	Pebble Count		McNeil Core		Cross Section		Rosgen Level II**	
	Composite % < 6mm (mean)	Riffle %<2mm (mean)	% <0.85mm	% <6.4 mm	Width / Depth Ratio (median)	Entrenchment Ratio (median)	E	P
DEQ-03	98%	97%	NA	NA	NA	NA	NA	B4/ E4
HFWY1-FS01	100%	NA	NA	NA	4.1	**3.4*****	E6	E5
HFWY7-FS01	88%	NA	NA	NA	**12.3**	**1.5*****	B5	E5
HFWY7	**54%**	20%	NA	NA	**13.5**	**1.6**	B4c	E4

***Bolded** values represent departure from water targets based on Rosgen Level II potential.
** E = Existing Stream Type & P = Potential Stream Type.
***NA = data not available
*** Forest Service Data based upon a single measure of entrenchment.

Table 5-20. Halfway Creek Sediment Data Compared to Supplemental Indicators.

Reach ID	BEHI Score (mean)	BEHI Adjective Rating	% Non-Eroding Banks	P.F. Condition	Residual Pool Depth (mean)	Pool Frequency (#/mile)	Large Woody Debris Frequency (#/mile)
HFWY1-FS01	N/A	N/A	N/A	FAR	N/A	N/A	N/A
HFWY7-FS01	N/A	N/A	N/A	**NF**	N/A	N/A	N/A
HFWY7	**41.8**	**Very High**	92.8	FAR	0.55	135	164

***Bolded** values represent departure from the water quality indicators for potential Rosgen stream type.

Table 5-21. 2005 Greenline Survey Data for Halfway Creek

Ground Cover	**HFWY7**
Rock/Root	17%
Riprap	
Bare Ground	22%
Herbaceous	62%
Wetland	
Understory	**HFWY7**
Deciduous	66%
Coniferous	2%
Mixed	6%
Overstory	**HFWY7**
Deciduous	
Coniferous	6%
Mixed	1%

Table 5-22. Biological Metrics for Halfway Creek
Bolded text failed to meet the target (Mountain MMI ≥ 63, Low Valley ≥ 48, and RIVPAC ≥ 0.80)

Station ID	**Date**	**Class**	**Mountain Index**	**RIVPACS O/E**
M08HFWYC01	10/14/2003	Low Valley	64.6	1.09

DEQ data generated from the 2003 reassessment of Halfway Creek reported riffle substrate < 6 mm at 98% and the percentage of fine particles < 2 mm at 97%. Rosgen stream type was not estimated for this data collection effort. However, assuming either a B4 or E4 stream type typical of this area, percent fines <6 mm and <2 mm both exceed target values. Conversely, macroinvertebrate samples taken at this location met target metrics.

At the uppermost survey site (HFWY1-FS01), the shift in Rosgen stream type from E5 to E6 suggests that increased deposition of surface fines are a problem. With a potential Rosgen stream type of E5, the W/D at HFWY1-FS01 was slightly greater than reference, while the entrenchment ratio was slightly less than expected. Measures above the expected W/D and below the expected entrenchment ratio suggests potential sediment problems; however, these comparisons alone do not lend overwhelming support of the sediment listing.

The water quality indicator value for composite surface sediments <6mm in Reach 7 was not within reference at the 2005 survey site, and possibly exceeded reference condition in 2001 along lower Halfway Creek (HFWY7 and HFWY7-FS01). In 2005 the percentage of composite surface fines <6 mm at HFWY7 was anywhere from 42% (E4) to 116% (B4) above reference depending on Rosgen stream type. The entrenchment ratios for both surveys in Reach 7 were less than expected for reference E and B type streams. The 2005 PFC rating for this section of Halfway Creek was also considered different from proposed reference conditions. The 2005 BEHI survey indicates that bank erosion was greater than expected for potential reference and primarily attributable to human sources; however, the percent eroding banks target was met.

Macroinvertebrate data collected in October 2003 met select supplemental targets for the mountain and valley MMI scores, as well as supplemental RIVPACS values.

Summary and TMDL Development Determination
Fine surface sediments appear to be accumulating in riffles, and pool habitat may also be affected. However, natural levels of elevated fines in this area are common due to the highly erosive parent geology. That being said, a greater than expected W/D and lower than expected entrenchment ratios could equate to increased sediment loading from streambanks. Bank erosion did appear to be a problem within the 2005 survey reach (HFWY7). During the 2005 inventory many sediment sources related to human activities were documented, such as riparian grazing, roads/trails, and channel modifications (suspected beaver dam removal and placer mining).

Although some of the percent fines targets were not met, elevated fine sediment is likely naturally occurring. No sediment TMDL will be prepared for Halfway Creek at this time, and additional monitoring is recommended to evaluate the extent of naturally occurring fine sediment, the significance of human sources, and impacts to beneficial uses.

5.4.2.6. Hells Canyon Creek

Hells Canyon Creek was listed as impaired due to sedimentation/siltation on the 2006 303(d) List. This stream segment is also listed for physical substrate habitat alterations, which are a form of pollution commonly linked to sediment impairment. Hells Canyon Creek forms in the Highland Mountains on the Beaverhead-Deerlodge National Forest. It flows for approximately 13 miles to where it meets the Jefferson River.

Physical Condition and Sediment Sources
The channel forms of Hells Canyon Creek are predominantly controlled by landform structure, as well as historic and current land uses. The prominent landform geology, the Boulder Batholith, has resulted in valley bottom formation along weathered joints. The stream headwaters arise from steep slopes (A-type), changing to more moderate slopes downstream. The canyon valley bottom alternates between confined (B-type) and unconfined sections (C-type). Remnants of beaver dams were observed in the lower portions of the stream. The removal of beaver dams may have altered channel form (straightened, incised), and that channel type would probably have naturally trended towards an E-type in these areas (**Appendix C, Figure 2-31**). The 2004 aerial assessment documented various sediment sources, including riparian grazing and unpaved roads. The sources of flow alterations from water diversions and impacts from abandoned mines were taken from GIS layers that located water rights claims and abandoned mines. The GIS-identified sources were not field verified. Silviculture harvests occurred before 1983 upslope from and adjacent to Hells Canyon Creek. Harmful effects from this impact were not observed in the field. Loss of riparian habitat was generally associated with road development and grazing.

In 2005 DEQ performed a sediment and stream morphology assessment at two locations within the Hells Canyon Creek watershed. These assessment sites were located about 3 miles (HELLC3) and 6 miles (HELLC6) below the headwaters. In addition to the 2005 inventory, two channel surveys was completed by the Beaverhead-Deerlodge National Forest in 1998 (HELLC4-FS98 and HELLC6-FS98) (DEQ, 2006).

Comparison with Water Quality Targets
The existing data in comparison with the targets and supplemental indicators for Hells Canyon Creek are summarized in **Tables 5-23, 5-24,** and **5-25**.

Table 5-23. Hells Canyon Creek Sediment Data Compared to Targets*.

Reach ID	Pebble Count		McNeil Core		Cross Section		Rosgen Level II**	
	Composite % < 6mm (mean)	**Riffle %<2mm (mean)**	**% <0.85 mm**	**% <6.4 mm**	**Width / Depth Ratio (median)**	**Entrench ment Ratio (median)**	**E**	**P**
HELLC3	24%	21%	NA	NA	7.3	2.3	B4a	B4a
HELLC4 -FS98	**33%**	NA	NA	NA	18.9	**2.5**	C4b/ B4	C4
HELLC6	21%	11%	**16%**	**40%**	13.0	**1.6**	B4c	E4 or C4
HELLC6 -FS98	**29%**	NA	NA	NA	14.2	**2.4**	C4b	C4
HELLC9	NA	NA	10%	**34%**	NA	NA	NA	NA

*__Bolded__ text values represent departure from the water quality indicators for potential Rosgen stream type.
** E = Existing Stream Type & P = Potential Stream Type.
*** Forest Service Data based upon a single measure of entrenchment.

Table 5-24. Hells Canyon Creek Sediment Data Compared to Supplemental Indicators.

Reach ID	BEHI Score (mean)	BEHI Adjective Rating	% Non-Eroding Banks	P.F. Condition	Residual Pool Depth (mean)	Pool Frequency (#/mile)	Large Woody Debris Frequency (#/mile)
HELLC3	**31.36**	**High**	91.6	PFC	0.75	76	276
HELLC4-FS98	NA	NA	NA	FAR	NA	NA	NA
HELLC6	**43.7**	**Very High**	99.3	**FAR**	0.85	88	0
HELLC6-FS98	NA	NA	NA	FAR	NA	NA	NA
HELLC9	NA	NA	NA	NA	NA	NA	NA

*__Bolded__ values represent departure from the water quality indicators for potential Rosgen stream type.

Table 5-25. 2005 Greenline Survey Data for Hells Canyon Creek

Ground Cover	**HELLC3**	**HELLC6**
Riprap		3%
Bare Ground	18%	11%
Herbaceous	13%	73%
Wetland	70%	14%
Understory	**HELLC3**	**HELLC6**
Deciduous	16%	26%
Coniferous	23%	
Mixed	14%	
Overstory	**HELLC3**	**HELLC6**
Deciduous	11%	
Coniferous	42%	
Mixed	14%	

Many of the selected sediment water quality indicator values were judged to be outside of reference or at the threshold for the survey sites along Hells Canyon Creek. The percentage of surface fines <2 mm at HELLC3 was 6% greater than the defined reference mean. The percentage of composite surface fines <6 mm at HELLC4-FS98 was anywhere from 14% (C4) to 32% (B4) greater, depending on Rosgen stream type. The W/D at HELLC4-FS98 was less than reference C4 type streams, while the entrenchment ratio was 82% less than expected for reference C4 type streams. At HELLC6 the entrenchment ratio was 16% less than expected and 89% less then the potential C4 stream type. The percentage of subsurface fines <6.4 mm for HELLC6 was 33% greater than the defined reference mean, while the percentage of fines (<0.85 mm) was 60% greater. The PFC rating at HELLC6 was also considered a violation of proposed reference conditions, due to the potential downward trend given current and historical management activities. Composite surface fines <6 mm at HELLC6-FS98 were at the threshold for reference, while the entrenchment ratio was 82% less than expected for reference. At HELLC9 the percentage of subsurface fines <6.4 mm for this site was 13% greater than the defined reference mean, while the percentage of fines (<0.85 mm) was at the threshold for the defined reference value.

Summary and TMDL Development Determination

Based on the data reviewed for Hells Canyon Creek, instream habitats for aquatic life and coldwater fisheries beneficial uses are likely impacted and affected by sediment. Fine surface sediments appear to be accumulating in riffles, and pool habitat may also be affected. Elevated surface fines in riffles can harm aquatic insects. In addition, subsurface sediments appear to be accumulating in fish spawning habitats. High fines in spawning gravels can disrupt and even prevent trout reproduction. Land disturbance appears to exacerbate erosion in the Boulder Batholith geology and the poorly developed soils of this subwatershed. During the 2004 and 2005 assessments many sediment sources related to human activities were documented, such as road inputs, riparian grazing, and channel modifications (suspected beaver dam removal, rip-rap, and historic logging alterations). This information supports the 303(d) listing, and a sediment TMDL will be completed for Big Pipestone Creek.

5.4.2.7. Little Pipestone Creek

Little Pipestone Creek was listed as impaired due to sedimentation/siltation on the 2006 303(d) List. This stream segment is also listed for alteration in stream-side or littoral vegetative covers, which are forms of pollution commonly linked to sediment impairment. Little Pipestone Creek originates on the Continental Divide in the Beaverhead-Deerlodge National Forest. It flows for approximately 16 miles to where it meets Big Pipestone Creek.

Physical Condition and Sediment Sources
The channel forms of Upper Little Pipestone Creek are predominantly controlled by landform structure, as well as historical and current land use activities. The uppermost portion of the headwaters area consists of flooded wet meadows that transition into a flowing stream. There were ponded areas from earthen dams and some areas of multiple threads with E-type channel characteristics. The upper reaches of the stream are affected by channelization between Montana Highway 2 and the railway. Channel forms in these confined areas were characteristic of E- and mostly G-type streams (**Appendix C, Figure 2-34**). The Boulder Batholith is the prominent geology of the upper reaches. Many pollution sources observed along Upper Little Pipestone Creek were related to roads and riparian grazing. In many instances, the sources of flow alterations from water diversions and impacts from abandoned mines were taken from GIS layers that located water rights claims and abandoned mines. The GIS-identified sources were not field verified, except in the uppermost reaches of the stream where earthen dams were observed obstructing the channel.

The channel forms of Lower Little Pipestone Creek are also predominantly controlled by landform structure and historical and current land use activities. The predominant valley type (VIII) would typically result in an unconfined stream type (C or E), yet channel alterations have resulted in stream types out of balance with the valley type (**Appendix C, Figure 2-35**). Active beaver dams were observed on the creek above Montana Highway 41. Many pollution sources observed along Lower Little Pipestone Creek were related to agricultural operations and rural housing development. Alterations for irrigation diversions were also observed. During the field source assessment, grazing impacts and flow alterations were observed, and in general, stream condition deteriorates in a downstream direction.

In 2005 DEQ performed a sediment and stream morphology assessment at two locations within the Little Pipestone Creek watershed. These sites, LTLP6 and LTLP9, were located about 7.5 and 12 miles below the headwaters. In addition to the 2005 inventory, one channel survey was completed by the Beaverhead-Deerlodge National Forest in 2001 (LTLP3-FS01) (DEQ, 2006).

Biological Data
In 2003 DEQ collected macroinvertebrate samples at two sites on Little Pipestone Creek. The bioassessment scores are presented in **Table 5-30**.

Comparison with Water Quality Targets
The existing data in comparison with the targets and supplemental indicators for Little Pipestone Creek are summarized in **Tables 5-26, 5-27, 5-28,** and **5-29**.

Table 5-26. Little Pipestone Creek Sediment Data Compared to Targets*.

Reach ID	Pebble Count		McNeil Core		Cross Section		Rosgen Level II**	
	Composite % < 6mm (mean)	**Riffle %<2mm (mean)**	**% <0.85 mm**	**% <6.4 mm**	**Width / Depth Ratio (median)**	**Entrenchment Ratio (median)**	**E**	**P**
LTLP3-FS01	**60%**	NA	NA	NA	6.9	**1.1**	G4c	E4
LTLP6	**52%**	**23%**	NA	NA	10.7	**1.4**	B4a	B4a
LTLP9	**46%**	**23%**	NA	NA	**8.2**	**2.4**	E4	E4

***Bolded** values represent departure from the water quality indicators for potential Rosgen stream type.
** E = Existing Stream Type & P = Potential Stream Type.
*** Forest Service Data based upon a single measure of entrenchment.

Table 5-27. Little Pipestone Creek Sediment Data Compared to Supplemental Indicators.

Reach ID	BEHI Score (mean)	BEHI Adjective Rating	% Non-Eroding Banks	P.F. Condition	Residual Pool Depth (mean)	Pool Frequency (#/mile)	Large Woody Debris Frequency (#/mile)
LTLP3-FS01	NA	NA	NA	NF	NA	NA	NA
LTLP6	**29.8**	**High**	98.2	FAR	0.86	186	182
LTLP9	**35.8**	**High**	85.9	FAR	0.86	100	76

***Bolded** values represent departure from the water quality indicators for potential Rosgen stream type.

Table 5-28. 2005 Greenline Survey Data for Little Pipestone Creek

Ground Cover	LTLP6	LTLP9
Rock/Root	41%	17%
Riprap	2%	1%
Bare Ground	3%	27%
Herbaceous	28%	38%
Wetland	27%	18%
Understory	**LTLP6**	**LTLP9**
Deciduous	89%	31%
Coniferous	2%	8%
Mixed	2%	4%
Overstory	**LTLP6**	**LTLP9**
Deciduous	9%	40%
Coniferous	20%	1%
Mixed	7%	1%

Table 5-29. Biological Metrics for Little Pipestone Creek
Bolded text failed to meet the target (Mountain MMI ≥ 63, Low Valley ≥ 48, and RIVPAC ≥ 0.80)

Station ID	Date	Class	Mountain Index	RIVPACS O/E
M08LTPSC04	7/17/2000	Mountains	**62**	**0.76**
M08LTPSC05	7/17/2000	Mountains	**52**	0.88

At the uppermost survey site (LTLP3-FS01), the shift in Rosgen stream type from E4 to G4c may support the conclusion that surface fines are a problem. With a potential Rosgen stream type of E4, the entrenchment ratio at LTLP3-FS01 was 93% less than expected. Beaverhead-Deerlodge National Forest reference data are not available for G type streams, but the percent of surface fines <6mm composite count has exceeded the E4 value. A lower than expected entrenchment ratio and high composite surface fines value support the conclusion of sediment impairment. Additionally, the PFC evaluation rated the reach as non-functional.

The 2005 data for Little Pipestone Creek reveal that the water quality indicator values for surface sediments and many of the channel morphology measures were not within reference. The percentage of surface fines <2 mm at LTLP6 was 16% greater than the defined reference mean, while the percentage of composite surface fines <6 mm was 108% greater. At LTLP6 the reach median entrenchment ratio was 26% less than expected. At LTLP9 the percentage of surface fines <2 mm was 15% greater than the defined reference mean, while the percentage of composite surface fines <6 mm was 21% greater. The W/D ratio was 17% greater than expected and the entrenchment ratio was 85% less than expected at LTLP9. The PFC ratings were not considered exceedences of the reference conditions, given that trends were either not discernable (LTLP6) or appeared to be improving (LTLP9). Additionally, the BEHI survey at LTLP9 indicates that bank erosion was greater than expected and primarily attributable to human-induced, although potentially historic sources.

Macroinvertebrate data collected in July 2003 were slightly below supplemental targets for the mountain (>63) MMI scores, though the supplemental RIVPACS values were met.

Summary and TMDL Development Determination
The results for Little Pipestone Creek indicate an increased sediment supply and a decreased capacity to transport sediment. Available sediment and habitat data suggest that fine sediment deposition is likely impacting fish spawning and rearing habitat and the aquatic macroinvertebrate assemblages that support the fishery. The primary human sources of sediment within the watershed include rangeland and near-stream grazing, bank erosion, and unpaved and paved roads. This information supports the 303(d) listing, and a sediment TMDL will be completed for Little Pipestone Creek.

5.4.2.8. Whitetail Creek

Whitetail Creek was listed as impaired due to sedimentation/siltation on the 2006 303(d) List. This stream segment is also listed for alteration in stream-side or littoral vegetative covers, which are forms of pollution commonly linked to sediment impairment. Whitetail Creek forms at the outlet of Whitetail Reservoir on the Beaverhead-Deerlodge National Forest. It flows for approximately 23 miles to where it meets the Jefferson Slough, a former channel of the Jefferson River.

Physical Condition and Sediment Sources

The channel forms of Upper Whitetail Creek are predominantly controlled by landform structure and flow releases from Whitetail Reservoir. The landform geology of this area includes the Boulder Batholith, while intrusive volcanic rocks are also apparent. The headwaters arise in Whitetail Park at the outlet of Whitetail Reservoir (C-type), then the stream flows through a steep, narrow canyon (A-type). The canyon gradient lessens and valley bottom openings alternate between relatively confined (B-type reaches) and unconfined areas (C-type reaches) (**Appendix C, Figure 2-40**). Sediment sources noted during the 2004 aerial and pollution source assessment include impacts from riparian grazing and unpaved roads. Impacts due to water diversions and mining activities were noted but not field verified.

The channel forms of Lower Whitetail Creek are controlled by landform and historical and current land use activities. The predominant valley type (VIII) would typically result in an unconfined stream type (C or E). Yet alterations for flow diversions and possibly removal of beaver dams have resulted in sections with channel types out of balance with the valley type. After the confluence with Little Whitetail Creek, sinuosity greatly increases, and the stream was thought to exhibit an E-type channel (**Appendix C, Figure 2-41**). Active beaver dams were observed in the lowermost reaches of Whitetail Creek. There was also a notable difference in beaver management along the stream, depending on individual landowner, with beaver dams concentrated in some areas and totally absent in others. It is possible that active beaver dams, as well as beaver dam removal, have resulted in diverse channel forms, such as braided sections and incised sections. Within the lower portions of the creek many pollution sources were observed during the 2004 aerial and pollution source assessment. These sources were primarily related to agricultural operations. During the field source assessment, grazing impacts were observed in all of the field surveyed reaches. In addition, irrigation diversion impacts were also noted.

In 2004 DEQ conducted a water quality assessment at two locations within the watershed. This assessment provided the majority of data used for updates to the water body's listing status in 2006. Other qualitative information relevant to excess sediment production was noted in the file at these locations and includes trampled banks and the influence of human activities exacerbating the highly erosive geology.

In 2005 DEQ performed sediment and stream morphology assessments at three locations within the Whitetail Creek watershed. These sites, WHTL5, WHTL14, and WHTL16, were located approximately 5, 12, and 19.5 miles below the outlet of Whitetail Reservoir. In addition to the 2005 inventory, two channel surveys were completed by the Beaverhead-Deerlodge National

Forest in 1999 and 2001 (WHTL4-FS01 and WHTL11-FS99)(DEQ, 2006). These sites were located approximately 3 and 10 miles below the outlet of Whitetail Reservoir.

Biological Data
In 2003 DEQ collected macroinvertebrate samples at two sites on Whitetail Creek. The bioassessment scores are presented in **Table 5-33**.

Comparison with Water Quality Targets
The existing data in comparison with the targets and supplemental indicators for Whitetail Creek are summarized in **Tables 5-30, 5-31, 5-32,** and **5-33**.

Table 5-30. Whitetail Creek Sediment Data Compared to Targets*.

Reach ID	**Pebble Count**		**McNeil Core**		**Cross Section**		**Rosgen Level II****	
	Composite % < 6mm (mean)	**Riffle %<2mm (mean)**	**% <0.85mm**	**% <6.4 mm**	**Width / Depth Ratio (median)**	**Entrenchment Ratio (median)**	**E**	**P**
DEQ Upper	**54%**	**53%**	NA	NA	**NA**	**NA**	NA	B4/ C4
DEQ Lower	**80%**	**77%**	NA	NA	**NA**	**NA**	NA	B4/ C4
WHTL4-FS01	**62%**	NA	NA	NA	**17.0**	**1.8*** **	B5c	E5
WHTL5	**40%**	19%	**25.0 %**	**71.4 %**	**15.8**	**1.6**	B4c	E4 or C4
WHTL11-FS99	**44%**	NA	NA	NA	10.6	**1.7*****	B4c	C4
WHTL14	28%	9%	NA	NA	10.8	**1.8**	B4c	C4
WHTL16	**40%**	**35%**	NA	NA	**22.3**	**1.2**	F4	E4

***Bolded** values represent departure from the water quality indicators for potential Rosgen stream type.
** E = Existing Stream Type & P = Potential Stream Type.
*** Forest Service Data based upon a single measure of entrenchment.

Table 5-31. Whitetail Creek Sediment Data Compared to Supplemental Indicators.

Reach ID	BEHI Score (mean)	BEHI Adjective Rating	% Non-Eroding Banks	P.F. Condition	Residual Pool Depth (mean)	Pool Frequency (#/mile)	Large Woody Debris Frequency (#/mile)
WHTL4-FS01	NA	NA	NA	FAR	NA	NA	NA
WHTL5	**30.7**	**High**	**58.4**	FAR	1.01	88	117
WHTL11-FS99	NA	NA	NA	**NF**	NA	NA	NA
WHTL14	**30.9**	**High**	87.2	FAR	0.75	70	123
WHTL16	**33.3**	**High**	87.3	**NF**	0.96	65	6

***Bolded** values represent departure from the water quality indicators for potential Rosgen stream type.

Table 5-32. 2005 Greenline Survey Data for Whitetail Creek

Ground Cover	**WHTL5**	**WHTL14**	**WHTL16**
Rock/Root	31%	18%	7%
Riprap	0	0	8%
Bare Ground	46%	12%	13%
Herbaceous	25%	71%	71%
Wetland	0	0	2%
Understory	**WHTL5**	**WHTL14**	**WHTL16**
Deciduous	35%	35%	41%
Coniferous	8%	7%	0
Mixed	6%	2%	0
Overstory	**WHTL5**	**WHTL14**	**WHTL16**
Deciduous	0	49%	0
Coniferous	31%	0	0
Mixed	31%	18%	7%

Table 5-33. Biological Metrics for Whitetail Creek
Bolded text failed to meet the target (Mountain MMI ≥ 63, Low Valley ≥ 48, and RIVPAC ≥ 0.80)

Station ID	Date	Class	Mountain Index	RIVPACS O/E
M08WHITC01	6/9/2004	Mountains	63	1.00
M08WHITC02	6/9/2004	Mountains	32.2	1.13

The 2004 DEQ reassessment data reported riffle substrate percent fines smaller than 6 mm as 54% at the upper site to 80% at the lower site. The percentage of fine particles smaller than 2 mm increased from 53% at the upper site, to 77% at the lower assessment site. Rosgen stream type was not estimated for this data collection effort. However, assuming either a B4 or C4 stream type typical of this area, percent fines <6 mm and <2 mm both exceed the target value.

For the survey sites along Upper Whitetail Creek (Little Whitetail Creek, WHTL4-FS01, WHTL5, and WHTL11-FS99), the composite surface fines values <6 mm were elevated against the target values. At WHTL14 the composite surface fines were just below (3%) target values for a potential Rosgen stream type of C4, but exceeded the target values by 12% for its existing stream type B4. At WHTL5 the percentage of subsurface fines in McNeil core samples <6.4 mm was 138% greater than the defined reference mean, while the percentage of fine fines (<0.85 mm) was 150% greater. The reach median W/D at WHTL5 was slightly below the 75th percentile of reference B4 and C4 type streams, yet exceeded the target for E4. The PFC rating was indicative of a downward trend. Bank erosion also appeared to be a problem at WHTL5.

The entrenchment ratio values for most of the Upper Whitetail Creek survey sites were believed to have been different from reference due to hydromodification associated with Whitetail Reservoir operations. Under the assumption that reservoir operations were following reasonable land, soil, and water conservation practices, the entrenchment ratio values will not be considered a violation of proposed reference conditions.

At the lowermost survey site on Whitetail Creek (WHTL16), the PFC rating was not within reference conditions. The PFC assessment rated the reach as NF. Given a potential Rosgen stream type of E4, the percentage of composite surface fines <6 mm, the W/D, the entrenchment ratio, and the BEHI rating were not within reference. Pool infilling may also be occurring at WHTL16.

One of the two macroinvertebrate samples collected in June 2004 exceeded supplemental target values for the Mountain Index, and the second sample was near the target value.

Summary and TMDL Development Determination
These results indicate an increased sediment supply and a decreased capacity to transport sediment within the Whitetail Creek watershed. Available sediment and habitat data suggest that fine sediment deposition is likely impacting fish spawning and rearing habitat and the aquatic macroinvertebrate assemblages that support the fishery. The primary human sources of sediment within the watershed include rangeland and near-stream grazing, bank erosion, and unpaved roads. This information supports the 303(d) listing, and a sediment TMDL will be completed for Whitetail Creek.

5.5 TMDL Development Summary

Based on the comparison of existing conditions to water quality targets, 6 sediment TMDLs will be developed in the tributary streams of the Upper Jefferson TPA. **Table 5-34** summarizes the sediment TMDL development determinations and corresponds to **Table 1-1**, which contains the TMDL development status for all listed water body segments on the 2006 303(d) List. Water body segments with a TMDL development determination of “No” are recommended for additional review and/or monitoring and may require TMDL development in the future.

Table 5-34. Summary of TMDL development determinations

Stream Segment	Water Body #	TMDL Development Determination (Y/N)
Big Pipestone Creek, from headwaters to mouth (Jefferson River)	MT41D001_020	Y
Cherry Creek, from headwaters to mouth (Jefferson River)	MT41D002_090	Y
Fish Creek, from headwaters to mouth (Jefferson River)	MT41D003_070	Y
Fitz Creek, from headwaters to mouth (Whitetail Creek)	MT41D002_030	N
Halfway Creek, from headwaters to mouth (Big Pipestone Creek)	MT41D003_130	N
Hells Canyon Creek, from headwaters to mouth (Jefferson River)	MT41D003_030	Y
Little Pipestone Creek, from headwaters to mouth (Big Pipestone Creek)	MT41D003_220	Y
Whitetail Creek, from headwaters to mouth (Jefferson River)	MT41D003_050	Y

5.6 Source Quantification

This section summarizes the current sediment load estimates from three broad source categories: unpaved road erosion, stream bank erosion, and hillslope erosion. EPA sediment TMDL development guidance for source assessments state that the basic source assessment procedure includes compiling an inventory of all sources of sediment to the water body and using one or more methods to determine the relative magnitude of source loading, focusing on the primary and controllable sources of loading (EPA 1999). Additionally, regulations allow that loadings “may range from reasonably accurate estimates to gross allotments, depending on the availability of data and appropriate techniques for predicting the loading” (Water quality planning and management, 40 CFR § 130.2(G)). The source assessment conducted for this TMDL evaluated loading from the primary sediment sources using standard DEQ methods. But the sediment loads presented herein represent relative loading estimates within each source category, and, as no calibration has been conducted, should not be considered as actual loading values. Rather, relative estimates provide the basis for percent reductions in loads for each source category. Until better information is available, and the linkage between loading and instream conditions becomes clearer, the loading estimates presented here should be considered as an evaluation of the relative contribution from sources and areas that will be further refined in the future through adaptive management

5.6.1 Upland Erosion

Based on source assessment, hillslope erosion contributes approximately 7,300 tons per year to sediment listed tributary streams in the Upper Jefferson TPA. This assessment indicates that rangeland grazing on the “grasslands/herbaceous” and “shrubland” cover types is the most

significant contributor to accelerated hillslope erosion within these tributary watersheds. Sediment loads due to hillslope erosion range from 85 tons/year in Halfway Creek watershed to 2,852 tons/year in the Whitetail Creek watershed. Since this assessment was conducted at the watershed scale, it is expected that larger watersheds will have greater sediment loads. Sediment loads normalized to watershed area are included in **Appendix D** and **E**. A significant portion of the sediment load due to hillslope erosion is contributed by natural sources. **Figure 5-2** contains annual sediment loads from upland erosion in 303(d) listed watersheds. **Appendix D** and **E** contain additional information about sediment loads from upland erosion in the Upper Jefferson TPA by subwatershed, including all 6th code HUCs in the TPA.

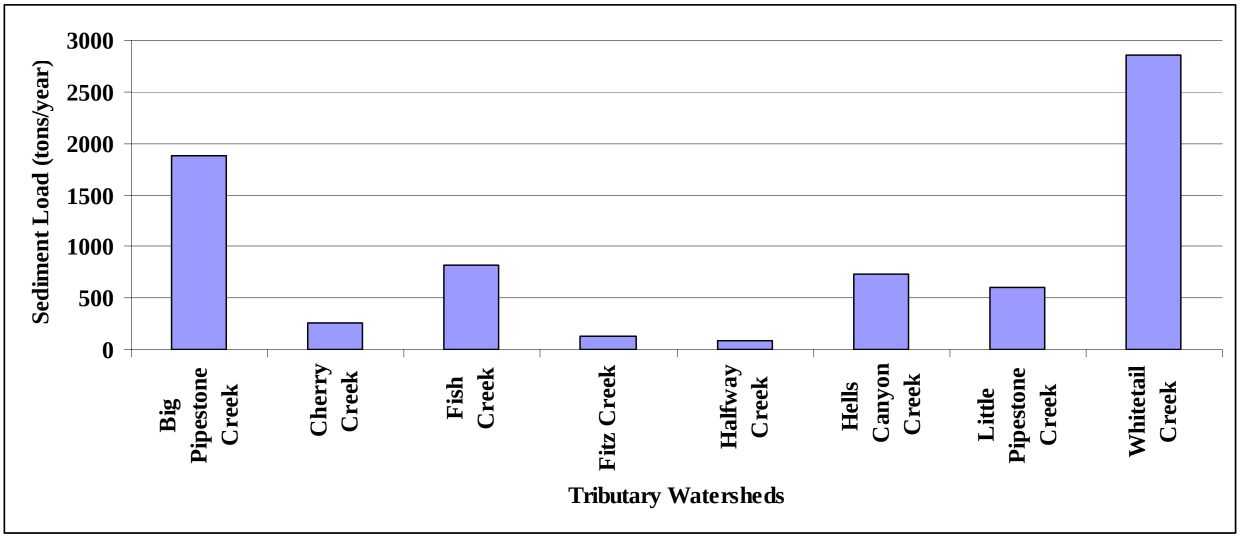

Figure 5-2. Existing Annual Sediment Load (tons/year) from Upland Erosion by 303(d) Listed Watershed within the Upper Jefferson TPA

5.6.2 Unpaved Roads

Based on the source assessment, unpaved roads are estimated to contribute 342 tons of sediment per year to sediment listed tributary streams in the Upper Jefferson TPA. Sediment loads due to unpaved roads range from 8 tons/year in the Halfway Creek watershed to 102 tons/year in the Big Pipestone Creek watershed. Factors influencing sediment loads from unpaved roads at the watershed scale include the overall road density within the watershed and the configuration of the road network, along with factors related to road construction and maintenance**. Figure 5-3** contains annual sediment loads from unpaved roads in 303(d) sediment listed watersheds. **Appendix F** contains additional information about sediment loads from unpaved roads in the Upper Jefferson TPA by subwatershed, including all that were assessed.

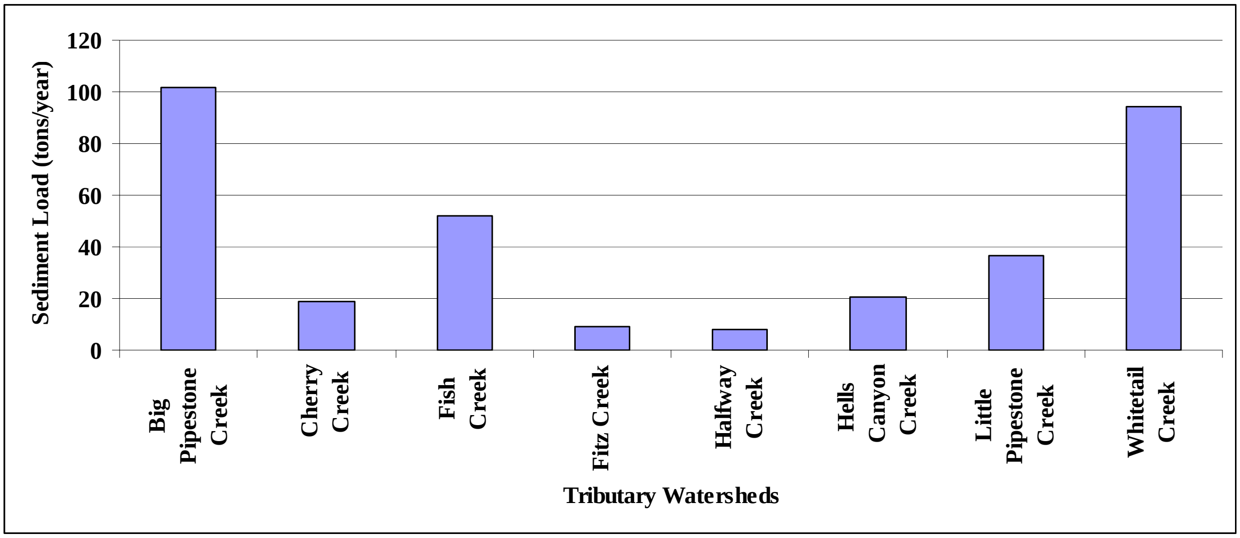

Figure 5-3. Existing Annual Sediment Load (tons/year) from Unpaved Roads in 303(d) Listed Tributary Watersheds within the Upper Jefferson TPA

5.6.3 Streambank Erosion

Based on the source assessment, streambank erosion contributes an estimated 20,745 tons of sediment per year to the Upper Jefferson TPA. Sediment loads due to streambank erosion range from 80 tons/year in the Fitz Creek watershed to 9,397 tons per year in the Big Pipestone Creek watershed. Within sediment listed tributary streams of the Upper Jefferson TPA, on average 46% of the sediment load due to streambank erosion is due to natural sources, while 54% is attributable to human sources. Significant sources of streambank erosion include riparian grazing (23%), irrigation shifts in stream energy (14%), transportation (6%), and cropping (5%). **Figure 5-4** contains annual sediment loads from eroding stream banks within 303(d) sediment listed watersheds. **Appendix G** contains additional information about sediment loads from eroding streambanks in the Upper Jefferson TPA by subwatershed, including all that were assessed.

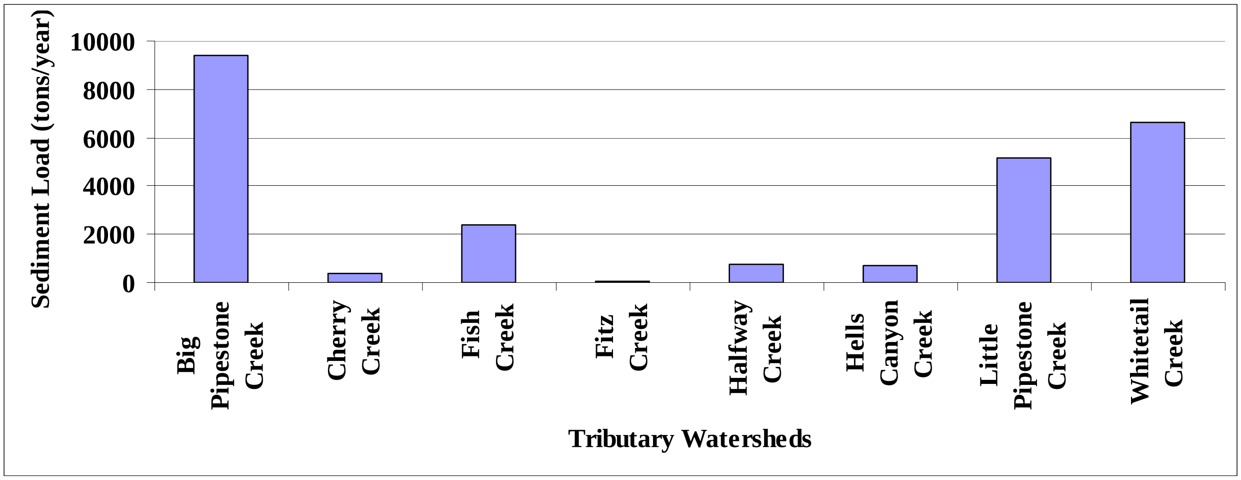

Figure 5-4. Existing Annual Sediment Load (tons/year) from Streambank Erosion by 303(d) Listed Tributary Watersheds within the Upper Jefferson TPA

5.6.4 Source Assessment Summary

The estimated annual sediment load from all identified sources within 2006 303(d) sediment listed tributary streams within the Upper Jefferson TPA is 28,434 tons. Each source type has different seasonal loading rates, and the relative percentage from each source category does not necessarily indicate its importance as a loading source. Additionally, the different source assessment methodologies introduce differing levels of uncertainty, as discussed in **Sections 5.3.6** and **5.8.3**. However, the modeling results for each source category, and the ability to proportionally reduce loading with the application of improved management practices (**Appendices D, E, F** and **G**), provide an adequate tool to evaluate the relative importance of loading sources (e.g., subwatersheds and/or source types) and to focus water quality restoration activities for this TMDL analysis.

5.7 TMDL and Allocations

The sediment TMDL process for the Upper Jefferson TPA will adhere to the TMDL loading function discussed in Section 4 but use a percent reduction in loading allocated among sources and an inherent margin of safety. A percent-reduction approach is used because there is uncertainty associated with the loads derived from the source assessment. Using the estimated sediment loads creates a rigid perception that the loads are absolutely conclusive. The percent-reduction TMDL approach constructs a plan that can be more easily understood for restoration planning. The TMDLs for sediment are stated as an overall percentage of the average annual sediment load that can be achieved by the sum of each individual allocation to a source. The sediment TMDLs use a percent-reduction allocation strategy based on estimates of BMP performances in the watershed.

Because there are no significant point sources, and sediment generally has a cumulative effect on beneficial uses, an annual expression of the TMDLs was determined as the most appropriate timescale to facilitate TMDL implementation. EPA encourages TMDLs to be expressed in the

most applicable timescale but also requires TMDLs to be presented as daily loads (Grumbles 2006); daily loads are provided in **Appendix H**.

The percent-reduction allocations are based on the modeled BMP scenarios for each major source type (e.g., unpaved roads, upland erosion, and streambank erosion) and reflect reasonable reductions as determined from literature, agency and industry documentation of BMP effectiveness, and field assessments. Sediment loading reductions are expected to be achieved through a combination of BMPs, and the most appropriate BMPs will vary by site. The allocation for roads was determined by assuming a reduction in the contributing length to 100 feet from each side of road crossings and 100 feet for near-stream roads. This is not a formal goal but an example of how reductions can be achieved. The Beaverhead-Deerlodge National Forest (BDNF) reference dataset indicates that a moderate BEHI score (20-29.5) can be expected on reference streams with the following stream types: A, C, (C3, C4), and E (E3, E4, E5, Ea) (Bengeyfield, 2004). Streams classified as B types are on the border of moderate and high (30.0-39.5) BEHI categories, with B3 streams falling into the moderate category and B4 streams falling into the high category. Based on the BDNF reference dataset, it was determined that functioning streams in the Upper Jefferson TPA would tend to have a moderate BEHI score. Therefore, the potential reduction associated with streambank erosion was derived by reducing the BEHI score for all assessed streambanks that exceeded the moderate category to a moderate BEHI score.

For streambanks with a moderate or lower BEHI score, no adjustment was made, and the resulting allocation is a 0% reduction. Often bank erosion sources are the result of historical land management activities that are not easily mitigated through changes in current management. Also, they can be costly to restore and damage is sometimes irreversible. Therefore, although the sediment load associated with bank erosion is presented in separate source categories (e.g., transportation, grazing, cropland), the allocation is presented as a percent reduction expected collectively from human sources. Streambank stability and erosion rates are largely a factor of the health of vegetation near the stream, and the reduction in bank erosion risk and sediment loading is expected to be achieved by applying BMPs within the riparian zone. Sediment load reductions at the watershed scale are based on the assumption that the same sources that affect a listed stream segment affect other streams within the watershed and that a similar percent sediment load reduction can be achieved by applying BMPs throughout the watershed.

Allocations for upland sediment sources were derived by modeling the reduction in sediment loads that will occur by increasing ground cover through the implementation of upland BMPs. In addition, further allocations were developed to account for the additional reduction in sediment loads that will occur by increasing the sediment trapping efficiency (i.e., health) of the vegetated riparian buffer through the implementation of riparian BMPs. This secondary allocation is focused on those sources that affect the overall health of the vegetated riparian buffer. Examples include providing off-site watering sources, limiting livestock access to streams, applying conservation tillage and precision farming, and establishing or enhancing riparian buffers. The allocation to these sources includes both present and past influences and is not meant to represent only current management practices. Many of the restoration practices that address current land use will reduce pollutant loads that are influenced from historic land uses. A significant portion of the remaining upland sediment loads after BMPs is also a component of the natural upland

load. However, the assessment methodology did not differentiate between sediment loads with all reasonable BMPs and natural loads. Additional information regarding BMPs for all source categories is contained in **Sections 6** and **7**.

5.7.1 Big Pipestone Creek

Big Pipestone Creek was listed as impaired due to sedimentation and siltation on the 2006 303(d) List. Sediment sources within the watershed include roads, streambank erosion, and upland erosion. Human sources of sediment to Big Pipestone Creek identified during this assessment include municipal and storm water point sources, roads/transportation, grazing, cropping, mining, irrigation shifts in stream energy, silviculture and "other," which refers to historical channel obstructions from historic mining.

The current annual sediment load is estimated at 11,402 tons/year, with an estimated 31% of the sediment load due to natural sources and 69% of the sediment load due to human sources (**Table 5-35**).

By applying BMPs, the sediment load to the Big Pipestone Creek watershed could be reduced to 6,157 tons/year. To achieve this reduction, a 62% sediment load reduction is allocated to unpaved roads, and a 10% reduction is allocated to gully wash and rill erosion from I-90. Streambank erosion is allocated a 67% reduction, while upland sediment sources are allocated a 59% reduction from grazing, a 91% reduction from croplands, and an additional 45% reduction from silviculture activities and other sources. Traditional upland BMPs and associated reductions were not allocated to silviculture activities and natural sources. However, their 45% reduction represents additional reductions in upland sediment sources gained through improved riparian health and increased riparian buffering capacity. Though not explicitly apparent, this reduction is also included within the reductions from other upland sources. For more information see **Appendix E.** This 45% reduction is allocated to those activities that influence the health and buffering capacity of the vegetated riparian buffer.

The total maximum daily sediment load for Big Pipestone Creek is expressed as a 46% reduction in the total average annual sediment load.

Table 5-35. Sediment Source Assessment, Allocations and TMDL for Big Pipestone Creek

Sediment Sources		**Current Estimated Load (Tons/Year)**	**Potential Estimated Sediment Load BMPs (Tons/Year)**	**Sediment Load Allocations (% reduction)**
Point Sources	Town of Whitehall WWTP	6	N/A	MPDES*
	Conda Mining, Inc	0	0	0%
Roads	Unpaved Roads All Ownership	102	39	62%
	I-90	21	19	10%
Streambank Erosion**	Transportation	961	317	67%
	Riparian Grazing	1926	636	67%
	Cropland	975	322	67%
	Mining	27	9	67%
	Irrigation	1377	454	67%
	Other Human Caused Sources	839	277	67%
	Natural Sources	3291	3291	0%
Upland Sediment Sources**	Grazing	1547	633	59%
	Crops	46	4	91%
	Silviculture	2	1	45%***
	Other****	282	155	45%***
Total Sediment Load		11402	6157	**46% = TMDL**

*Loads will be managed by following the MPDES permit requirements. A TSS reduction feasibility study will be initiated if the WWTP doubles current average annual loads.
**A significant portion of bank erosion, grazing lands, cropland and other loads have a “natural load” component incorporated into them.
***The load reduction derived solely by increasing the health and sediment buffering capacity of the vegetated riparian buffer.
****Defined as areas with little or no human activity bounded by riparian areas where human activities are “allowing” a higher loading than what could be achieved via riparian improvements.

5.7.2 Cherry Creek

Cherry Creek was listed as impaired due to sedimentation and siltation on the 2006 303(d) List. Sediment sources within the Cherry Creek watershed include roads, streambank erosion, and upland erosion. Human sources of sediment identified during this assessment include roads/transportation, grazing, cropping, and irrigation shifts in stream energy.

The current estimated annual sediment load is 627 tons/year, with an estimated 30% from natural sources and 70% from human sources (**Table 5-36**). By applying BMPs, the sediment load could

be reduced to 357 tons/year. To achieve this reduction, a 71% sediment load reduction is allocated to roads, while a 67% reduction is allocated to streambank erosion. Upland sediment sources are allocated a 55% reduction from grazing, a 62% reduction from croplands, and an additional 41% reduction in loading from other sources. Traditional upland BMPs and associated reductions were not allocated to other sources. However, their 41% reduction represents additional reductions in upland sediment sources gained through improved riparian health and increased riparian buffering capacity. Though not explicitly apparent, this reduction is also included within the allocations from other upland sources. For more information see **Appendix E.** This 41% reduction is allocated to those activities that influence the health and buffering capacity of the vegetated riparian buffer.

The total maximum daily sediment load for Cherry Creek is expressed as a 43% reduction in the total average annual sediment load.

Table 5-36. Sediment Source Assessment, Allocations and TMDL for Cherry Creek

Sediment Sources		**Current Estimated Load (Tons/Year)**	**Potential Estimated Sediment Load with BMPs (Tons/Year)**	**Sediment Load Allocations (% reduction)**
Roads	All Ownership	19	6	71%
Streambank Erosion*	Transportation	9	3	67%
	Riparian Grazing	85	28	67%
	Irrigation	87	29	67%
	Natural Sources	175	175	0%
Upland Sediment Sources*	Grazing	234	106	55%
	Crops	0.3	0.1	62%
	Other***	18	11	41%**
Total Sediment Load		627	357	**43% = TMDL**

*A significant portion of bank erosion, grazing lands, cropland and other loads have a “natural load” component incorporated into them.
**The load reduction derived solely by increasing the health and sediment buffering capacity of the vegetated riparian buffer.
***Defined as areas with little or no human activity bounded by riparian areas where human activities are “allowing” a higher loading than what could be achieved via riparian improvements.

5.7.3 Fish Creek

Fish Creek was listed as impaired due to sedimentation on the 2006 303(d) List. Sediment sources within the Fish Creek watershed include roads, streambank erosion, and upland erosion. Human sources of sediment identified during this assessment include roads/transportation, grazing, cropping, mining, irrigation shifts in stream energy, silviculture, and “other,” which refers to the influence of channel obstructions.

The current estimated annual sediment load is 3,264 tons/year, with an estimated 36% from natural sources and 64% from human sources (**Table 5-37**). By applying BMPs, the sediment load can be reduced to 2,077 tons/year. To achieve this reduction a 52% sediment load reduction is allocated to roads, while a 54% reduction is allocated to streambank erosion. Upland sediment sources are allocated a 56% reduction from grazing, a 73% reduction from croplands, and an additional 40% reduction in loading from silviculture activities and other sources. Traditional upland BMPs and associated reductions were not allocated to silviculture activities and other sources. However, their 40% reduction represents additional reductions in upland sediment sources through improved riparian health and increased riparian buffering capacity. Though not explicitly apparent, this reduction is also included within the reductions from other upland sources. For more information see **Appendix E.** This 40% reduction is allocated to those activities that influence the health and buffering capacity of the vegetated riparian buffer.

The total maximum daily sediment load for Fish Creek is expressed as a 36% reduction in the total average annual sediment load.

Table 5-37. Sediment Source Assessment, Allocations and TMDL for Fish Creek

Sediment Sources		**Current Estimated Load (Tons/Year)**	**Potential Estimated Sediment Load BMPs (Tons/Year)**	**Sediment Load Allocations (% reduction)**
Roads	All Ownership	52	25	52%
Streambank Erosion*	Transportation	241	111	54%
	Riparian Grazing	494	227	54%
	Cropland	213	98	54%
	Mining	5	2	54%
	Irrigation	363	167	54%
	Other	24	11	54%
	Natural Sources	1055	1055	0%
Upland Sediment Sources*	Grazing	690	306	56%
	Crops	3	1	73%
	Silviculture	2	1	40%**
	Other***	122	72	40%**
Total Sediment Load		3264	2077	**36% = TMDL**

*A significant portion of bank erosion, grazing lands, cropland and other loads have a “natural load” component incorporated into them.
**The load reduction derived solely by increasing the health and sediment buffering capacity of the vegetated riparian buffer.
***Defined as areas with little or no human activity bounded by riparian areas where human activities are “allowing” a higher loading than what could be achieved via riparian improvements.

5.7.4 Hells Canyon Creek

Hells Canyon Creek was listed as impaired due to sedimentation and siltation on the 2006 303(d) List. Sediment sources within the Hells Canyon Creek watershed include roads, streambank erosion, and upland erosion. Human sources of sediment identified during this assessment include roads/transportation, grazing, irrigation shifts in stream energy and "other," which refers to channel incision.

The current estimated annual sediment load is 1,473 tons/year, with an estimated 32% from natural sources and 68% from human sources (**Table 5-38**). By applying BMPs, the sediment load can be reduced to 947 tons/year. To achieve this reduction, a 38% sediment load reduction is allocated to roads, while a 67% reduction is allocated to streambank erosion. Upland sediment sources are allocated a 44% reduction from grazing and an additional 29% reduction in loading from other upland sources. Traditional upland BMPs and associated reductions were not allocated to other upland sources. However, the 29% reduction represents additional reductions in upland sediment sources through improved riparian health and increased riparian buffering capacity. Though not explicitly apparent, this reduction is also included within the reductions from other upland sources. For more information see **Appendix E.** This 29% reduction is allocated to those activities that influence the health and buffering capacity of the vegetated riparian buffer.

The total maximum daily sediment load for Hells Canyon Creek is expressed as a 36% reduction in the total average annual sediment load.

Table 5-38. Sediment Source Assessment, Allocations and TMDL for Hells Canyon Creek

Sediment Sources		**Current Estimated Load (Tons/Year)**	**Potential Estimated Sediment Load BMPs (Tons/Year)**	**Sediment Load Allocations (% reduction)**
Roads	All Ownership	21	13	38%
Streambank Erosion*	Transportation	19	6	67%
	Riparian Grazing	223	74	67%
	Irrigation	45	15	67%
	Other	20	6	67%
	Natural Sources	421	421	0%
Upland Sediment Sources*	Grazing	668	371	44%
	Other ***	57	41	29%**
Total Sediment Load		1473	947	**36% = TMDL**

*A significant portion of bank erosion, grazing lands, cropland and other loads have a "natural load" component incorporated into them.
**The load reduction derived solely by increasing the health and sediment buffering capacity of the vegetated riparian buffer.
***Defined as areas with little or no human activity bounded by riparian areas where human activities are "allowing" a higher loading than what could be achieved via riparian improvements.

5.7.5 Little Pipestone Creek

Little Pipestone Creek was listed as impaired due to sedimentation and siltation on the 2006 303(d) List. Sediment sources within the Little Pipestone Creek watershed include roads, streambank erosion, and upland erosion. Human sources of sediment identified during this assessment include roads/transportation, grazing, cropping, irrigation shifts in stream energy, silviculture and “other,” which refers to the influence of upstream channelization and flow modifications.

The current estimated annual sediment load is 5,812 tons/year, with an estimated 35% from natural sources and 65% from human sources (**Table 5-39**). By applying BMPs, the sediment load can be reduced to 3,461 tons/year. To achieve this reduction, a 40% sediment load reduction is allocated to roads, while a 61% reduction is allocated to streambank erosion. Upland sediment sources are allocated a 63% reduction from grazing, an 83% reduction from croplands, and an additional 51% reduction in loading from silviculture activities and other sources. Traditional upland BMPs and associated reductions were not allocated to silviculture activities and other sources. However, their 51% reduction represents additional reductions in upland sediment sources through improved riparian health and increased riparian buffering capacity. Though not explicitly apparent, this reduction is also included within the reductions from other upland sources. For more information see **Appendix E.** This 51% reduction is allocated to those activities that influence the health and buffering capacity of the vegetated riparian buffer.

The total maximum daily sediment load for Little Pipestone Creek is expressed as a 41% reduction in the total average annual sediment load.

Table 5-39. Sediment Source Assessment, Allocations and TMDL for Little Pipestone Creek

Sediment Sources		**Current Estimated Load (Tons/Year)**	**Potential Estimated Sediment Load BMPs (Tons/Year)**	**Sediment Load Allocations (% reduction)**
Roads	All Ownership	37	22	40%
Streambank Erosion*	Transportation	646	252	61%
	Riparian Grazing	839	327	61%
	Cropland	594	232	61%
	Irrigation	442	172	61%
	Other	708	276	61%
	Natural Sources	1947	1947	N/A
Upland Sediment Sources*	Grazing	534	197	63%
	Crops	1.50	0.25	83%
	Silviculture	0.39	0.19	51%**
	Other***	73	35	51%**
Total Sediment Load		5821	3461	**41% = TMDL**

*A significant portion of bank erosion, grazing lands, cropland and other loads have a "natural load" component incorporated into them.
**The load reduction derived solely by increasing the health and sediment buffering capacity of the vegetated riparian buffer.
***Defined as areas with little or no human activity bounded by riparian areas where human activities are "allowing" a higher loading than what could be achieved via riparian improvements.

5.7.6 Whitetail Creek

Whitetail Creek was listed as impaired due to sedimentation on the 2006 303(d) List. Sediment sources include roads, streambank erosion, and upland erosion. Human sources of sediment to Whitetail Creek identified during this assessment include roads/transportation, grazing, irrigation shifts in stream energy, silviculture and "other," which refers to channel incision.

The current estimated annual sediment load is 9,569 tons/year, with an estimated 23% from natural sources and 77% from human sources (**Table 5-40**). By applying BMPs, the sediment load can be reduced to 5,293 tons/year. To achieve this reduction, a 66% sediment load reduction is allocated to roads, while a 57% reduction is allocated to streambank erosion. Upland sediment sources are allocated a 55% reduction from grazing, a 93% reduction from croplands, and an additional 42% reduction in loading from silviculture activities and other sources. Traditional upland BMPs and associated reductions were not allocated to silviculture activities and other sources. However, their 42% reduction represents additional reductions in upland sediment sources through improved riparian health and increased riparian buffering capacity. Though not explicitly apparent, this reduction is also included within the reductions from other upland sources. For more information see **Appendix E.** This 42% reduction is allocated to those activities that influence the health and buffering capacity of the vegetated riparian buffer.

The total maximum daily sediment load for Whitetail Creek is expressed as a 45% reduction in the total average annual sediment load.

Table 5-40. Sediment Source Assessment, Allocations and TMDL for Whitetail Creek

Sediment Sources		**Current Estimated Load (Tons/Year)**	**Potential Estimated Sediment Load BMPs (Tons/Year)**	**Sediment Load Allocations (% reduction)**
Roads	All Ownership	94	32	66%
Streambank Erosion*	Transportation	500	215	57%
	Riparian Grazing	1650	710	57%
	Cropland	887	382	57%
	Irrigation	1358	584	57%
	Other	251	108	57%
	Natural Sources	1977	1977	0%
Upland Sediment Sources*	Grazing	2490	1122	55%
	Crops	90	6	93%
	Silviculture	2.14	1.25	42%**
	Other ****	270	158	42%**
Total Sediment Load		9569	5293	**45% = TMDL**

*A significant portion of bank erosion, grazing lands, cropland and other loads have a "natural load" component incorporated into them.
**The load reduction derived solely by increasing the health and sediment buffering capacity of the vegetated riparian buffer.
***Defined as areas with little or no human activity bounded by riparian areas where human activities are "allowing" a higher loading than what could be achieved via riparian improvements.

5.8 Seasonality and Margin of Safety

All TMDL documents must consider the seasonal variability, or seasonality, on water quality impairment conditions, maximum allowable pollutant loads in a stream (TMDLs), and load allocations. TMDL development must also incorporate a margin of safety into the load allocation process to account for uncertainties in pollutant sources and other watershed conditions, and to ensure (to the degree practicable) that the TMDL components and requirements are sufficiently protective of water quality and beneficial uses. This section describes seasonality and margin of safety in the Upper Jefferson TPA tributary sediment TMDL development process.

5.8.1 Seasonality

The seasonality of sediment impact to aquatic life is taken into consideration in the analysis within this document. Sediment loading varies considerably with season. For example, sediment delivery increases during spring when snowmelt delivers sediment from upland sources and the resulting higher flows scour streambanks. However, these higher flows also scour fines from streambeds and sort sediment sizes, resulting in a temporary decrease in the proportion of deposited fines in critical areas for fish spawning and insect growth. While fish are most susceptible to fine sediment deposition seasonally during spawning, fine sediment may affect aquatic insects throughout the year. Because both fall and spring spawning salmonids reside in the Upper Jefferson TPA, streambed conditions need to support spawning through all seasons. Additionally, reduction in pool habitat, by either fine or coarse sediment, alters the quantity and quality of adult fish habitat and can, therefore, affect the adult fish population throughout the year. Thus, sediment targets are not set for a particular season, and source characterization is geared toward identifying average annual loads. Annual loads are appropriate because the impacts of delivered sediment are a long-term impact—once sediment enters the stream network, it may take years for sediment loads to move through a watershed. Although an annual expression of the TMDLs was determined as the most appropriate timescale to facilitate TMDL implementation, to meet EPA requirements daily loads are provided in **Appendix H**.

5.8.2 Margin of Safety

Incorporating a margin of safety (MOS) is a required component of TMDL development. The MOS accounts for the uncertainty between pollutant loading and water quality and is intended to ensure that load reductions and allocations are sufficient to sustain conditions that will support beneficial uses. MOS may be applied implicitly by using conservative assumptions in the TMDL development process or explicitly by setting aside a portion of the allowable loading (EPA, 1999). This plan incorporates an implicit MOS in a variety of ways:

- By using multiple targets to help verify beneficial use support determinations and assess standards attainment after TMDL implementation. Conservative assumptions were used during target development (see **Section 5.4.1**).
- By using supplemental indicators, including biological indicators, to help verify beneficial use support determinations and assess standards attainment after TMDL implementation. Conservative assumptions were used during supplemental indicator development (see **Section 5.4.1**).
- By using standards, targets, and TMDLs that address both coarse and fine sediment delivery.
- By using supplemental indicators that act as an early warning method to identify pollutant-loading threats, which may not otherwise be identified, if targets are not met. Conservative assumptions were used for the source assessment process, including erosion rates, sediment delivery ratio, and BMP effectiveness (see **Appendices D, E, F** and **G**).
- By considering seasonality (discussed above).
- By using an adaptive management approach to evaluate target attainment and allow for refinement of load allocation, targets, modeling assumptions, and restoration strategies to

further reduce uncertainties associated with TMDL development (discussed below and in **Section 6** and **7**).

- By using naturally occurring sediment loads as described in ARM 17.30.602(17) (see **Appendix B**) to establish the TMDLs and allocations. This includes an allocation process that addresses all known human sediment causing activities, not just the significant sources.

5.8.3 Uncertainty and Adaptive Management

A degree of uncertainty is inherent in any study of watershed processes related to sediment. The assessment methods and targets used in this study to characterize impairment and measure future restoration are each associated with a degree of uncertainty. This TMDL document will include a monitoring and adaptive management plan to account for uncertainties in the field methods, targets, and supplemental indicators. For the purpose of this document, adaptive management relies on continued monitoring of water quality and stream habitat conditions, continued assessment of impacts from human activities and natural conditions, and continued assessment of how aquatic life and coldwater fish respond to changes in water quality and stream habitat conditions. Adaptive management addresses important considerations, such as feasibility and uncertainty in establishing targets. For example, despite implementation of all restoration activities (**Section 6**), the attainment of targets may not be feasible due to natural disturbances, such as forest fires, flood events, or landslides.

The targets established in the document are meant to apply under median conditions of natural background and natural disturbance. The goal is to ensure that management activities achieve loading approximate to the TMDLs within a reasonable timeframe and prevent significant excess loading during recovery from significant natural events. Additionally, the natural potential of some streams could preclude achievement of some targets. For instance, natural geologic and other conditions may contribute sediment at levels that cause a deviation from numeric targets associated with sediment. Conversely, some targets may be underestimates of the potential of a given stream and it may be appropriate to apply more protective targets upon further evaluations. Supplemental indicators are used to help with these determinations. In these circumstances, it is important to recognize that the adaptive management approach provides the flexibility to refine targets and supplemental indicators as necessary to ensure protection of the resource and to adapt to new information concerning target achievability.

Sediment limitations in many streams in the Upper Jefferson TPA relate to a fine sediment fraction found on the stream bottom, while sediment modeling employed in the Upper Jefferson TPA examined all sediment sizes. In general, roads and upland sources produce mostly fine sediment loads, while streambank erosion can produce all sizes of sediment. Because sediment source modeling may under- or over-estimate natural inputs due to selection of sediment monitoring sections and the extrapolation methods used, model results should not be taken as an absolutely accurate account of sediment production within each watershed. Instead, source assessment model results should be considered used as a tool to estimate sediment loads and make general comparisons of sediment loads from various sources.

Cumulatively, the source assessment methodologies address average sediment source conditions over long timeframes. Sediment production from both natural and human sources is driven by storm events. Pulses of sediment are produced periodically, not uniformly, through time. Separately, each source assessments methodology introduces different levels of uncertainty. For example, the road erosion method focuses on sediment production and sediment delivery locations from yearly precipitation events. The analysis did not include an evaluation of road culvert failures, which tend to add additional sediment loading during large flood events and would, therefore, increase the average yearly sediment loading if calculated over a longer time period. Road loading also tends to focus in upper areas of watersheds where there is often limited hillslope or bank erosion loading. The bank erosion method focuses on both sediment production and sediment delivery and also incorporates large flow events via the method used to identify bank area and retreat rates. Therefore, a significant portion of the bank erosion load is based on large flow events versus typical yearly loading. The hillslope erosion model focuses primarily on sediment production across the landscape during typical rainfall years. Sediment delivery is partially incorporated based on distance to stream (**Appendix C**). The significant filtering role of near-stream vegetated buffers (riparian areas) was incorporated into the hillslope analysis (**Appendix E**), resulting in proportionally reduced modeled sediment loads from hillslope erosion relative to the average health of the vegetated riparian buffer throughout the watershed.

Because the sediment standards relate to a water body's greatest potential for water quality given current and historic land use activities where all reasonable land, soil, and water conservation practices have been applied and resulting conditions are not harmful, detrimental, or injurious to beneficial uses, the percent-reduction allocations are based on the modeled upland and riparian BMP scenarios for each major source type. The allocations reflect reasonable reductions as determined from literature, agency and industry documentation of BMP effectiveness, and field assessments. However, if new information becomes available regarding the feasibility or effectiveness of BMPs, adaptive management allows for the refinement of TMDLs and allocations.

Additionally, as part of this adaptive management approach, shifts in the amount or intensity of land use activities should be tracked and incorporated into the source assessment to determine if allocations need to be revised. Cumulative impacts from multiple projects must also be considered. This approach will help track the recovery of the system and the impacts, or lack of impacts, from ongoing management activities in the watershed. Under these circumstances, additional targets and other types of water quality goals may need to be developed to address new stressors to the system, depending on the nature of the activity.

Undersized culverts are also a potential sediment source but were not assessed within the scope of this project. The risk of culvert failure is related to the frequency and size of storm events. Total failure can result in a large sediment pulse, but for undersized culverts, even smaller events can flush excess instream sediment downstream and cause culverts to become barriers to fish passage. Due to the uncertainty associated with sediment source assessment modeling, **Section 7** includes a monitoring and adaptive management plan to account for uncertainties in the source assessment results.

SECTION 6.0
FRAMEWORK FOR WATER QUALITY RESTORATION

6.1 Summary of Jefferson Restoration Strategy

This section provides a framework strategy for water quality restoration in the tributary streams of the Upper Jefferson River watershed, focusing on how to meet conditions that will likely achieve the TMDLs presented in this document. This section identifies which activities will contribute the most reduction in pollutants for each TMDL. Limited information about spatial application of each restoration activity will be provided.

This section should assist stakeholders in developing a more detailed adaptive Watershed Restoration Plan (WRP) in the future. The locally developed Watershed Restoration Plan will likely provide more detailed information about restoration goals and spatial considerations. The WRP may also encompass more broad goals than this framework includes. The to-be-developed WRP would serve as a locally organized "road map" for watershed activities, sequences of projects, prioritizing of projects, and funding sources for achieving local watershed goals, including water quality improvements. Within this plan, the local stakeholders would identify and prioritize streams, tasks, resources, and schedules for applying Best Management Practices (BMPs). As restoration experiences and results are assessed through watershed monitoring, stakeholders could adapt and revise this strategy based on new information and ongoing improvements.

6.2 Watershed Restoration Goals

The following are general water quality goals provided in this TMDL document:

- Provide technical guidance for full recovery of aquatic life beneficial uses to all impaired streams within tributary streams of the Upper Jefferson River TMDL Planning Area (TPA) by improving sediment water quality conditions. This technical guidance is provided by the TMDL components in the document.
- Identify a framework watershed restoration approach for activities that will attain sediment water quality standards in water bodies with TMDLs.
- Assess watershed restoration activities to address significant pollutant sources. Costs and benefits are both generally considered, although this analysis is not detailed. General spatial guidance will be provided for restoration activities.

A Watershed Restoration Plan (WRP) is a locally derived plan that can be more dynamic than the TMDL document. It can be refined as activities progress and address a much wider variety of goals than those included in this TMDL document. The following are key suggested elements for this stakeholder derived Watershed Restoration Plan (WRP):

- Implement Best Management Practices (BMPs) to protect water conditions so that all streams in the watershed maintain good quality, with an emphasis on waters with completed TMDLs.

- Develop more detailed cost-benefit and spatial considerations for water quality improvement projects.
- Develop an approach for future BMP installments and efficiency results tracking.
- Provide information and education to reach out to stakeholders about approaches to restoration, its benefits, and funding assistance.
- Include other watershed health goals as needed.

Specific water quality goals are detailed in **Section 5**. The targets are the basis for long-term effectiveness monitoring for achieving the above water quality goals (**Section 7**). These targets specify satisfactory conditions to ensure protection and/or recovery of beneficial uses for Upper Jefferson tributary waters. **Section 7** identifies a general approach to the monitoring recommendations designed to track post-implementation water quality conditions and restoration successes.

6.3 Framework Watershed Management Recommendations

Sediment TMDLs were completed for six tributary watersheds. The most important restoration approach for reducing sediment loading in the Upper Jefferson River TPA is streamside riparian restoration and long-term riparian zone management. Channel restoration might be necessary where riparian vegetation has been altered and/or irrigation systems have had a negative impact. Other sediment restoration actions would include controlling erosion from unpaved roads near streams and improving management of the I-90 corridor.

6.3.1 Sediment Restoration Approaches

Restoring riparian vegetation and long-term riparian area management are essential practices that must be implemented across the watershed to achieve the sediment TMDLs. Using native riparian vegetation (particularly woody plants) is recommended because these species have the best root mass to hold streambanks together. Suitable root mass density ultimately slows bank erosion. Riparian vegetation captures sediment from upland runoff. During flooding, sediment can deposit more heavily in healthy riparian zones because the vegetation slows water flow, allowing sediments to filter out before reaching the stream.

Most of the sediment TMDLs identify eroding banks due to human influences as the primary sediment source (**Table 6-1**). Riparian restoration will address bank erosion and include channel restoration in areas that have been heavily impacted. Livestock grazing in riparian areas is the predominant cause of riparian and stream channel degradation in the Upper Jefferson watershed. In numerous areas hay production encroaches into riparian zones, negatively impacting riparian vegetation. **Table 6-1** provides a summary of load reductions along with ranked sources and possible BMPs associated with each source. The table also identifies general spatial guidance for each watershed with a sediment TMDL. Also see **Appendix E**, **Figure E-3** for spatial considerations when contemplating riparian vegetation improvement projects.

Erosion from uplands due to human influences tends to be the second most predominant source of sediment identified in the TMDLs. The restoration objective is to improve riparian vegetation so that it captures more sediment and prevents it from reaching the stream. Thus, as stated above,

restoring riparian vegetation and implementing a long-term riparian management plan are key factors in reducing sediment.

On average, erosion from unpaved and paved roads is the third most controllable sediment source in the Upper Jefferson watershed. Restoration efforts should be designed to divert water from roads and ditches before it enters the stream. Diverted water can be routed through natural healthy vegetation, which filters out sediment before it can enter streams. Sediment from roads, as well as rill and gully wash erosion, may cause significant localized impacts in some stream reaches, even though, at a watershed scale, it may be a small to moderate source. Sediment from culvert failure and culvert-caused scour were not noted by the TMDL source assessment but should be considered in restoration efforts.

All of these BMPs are considered reasonable restoration approaches due to their benefit and generally low costs. Riparian protection/restoration and road erosion control are standard BMPs identified by NRCS and are not overly expensive. Many riparian areas could benefit from more active grazing management (possibly with some additional fencing) and would typically recover naturally. Active riparian vegetation planting, along with bank sloping, may be slightly more costly but still reasonable and relatively cost effective. When restoration is needed due to altered stream channels, costs increase and projects should be assessed on a case-by-case basis.

Historic placer mining, as well as irrigation infrastructure, may have localized impacts that affect sediment production within the watershed. If found, such sediment sources that can be restored at reasonable costs could be prioritized into the watershed restoration plan. Any other unknown sediment sources could also be incorporated into the restoration plan, while considering cost and sediment reduction benefits.

Through application of locally appropriate BMPs, sediment loads in individual streams can be reduced between 36% and 46% (**Table 6-1**).

Table 6-1. Summary of Sediment Load Reductions and Ranked Restoration Strategy by Watershed

Name of Water body	Current Sediment Loads (tons per year)	TMDL Sediment Load Reduction (% of total load)	Source and Restoration Rank	Ranked Controllable Sources	Ranked BMP Type	Spatial concerns
Big Pipestone Creek	6,612	57%	1	Eroding Banks needing sustainable riparian zone vegetative condition, Reduction in irrigation infrastructure effects	Riparian grazing management, Riparian willow vegetation restoration, Move haying from riparian green line, Irrigation infrastructure mitigation	Eroding banks with insufficient riparian cover occur along significant but intermittent reaches of both the lower and upper portions of the creek. Some riparian areas are managed well and others need riparian restoration work. Riparian health appears to be fair in upper portions of the watershed while health markedly declines to a mix of fair and poor in the lower portions. Tributaries should also be addressed to reduce sediment loads to Big Pipestone Creek. In both the lower and upper portions of the watershed, effects from Irrigation infrastructure are apparent. Spatial considerations are provided in Appendix E & G
			2	Upland Sediment from grazing,	Riparian grazing management, Provide filter strips along streams	
			3	Paved and Unpaved roads	Road maintenance and runoff BMPs	Road maintenance BMPs should occur on I-90 and many unpaved road crossings. Spatial considerations are provided in Appendix C & F.
Cherry Creek	2,759	41%	1	Upland Sediment from grazing	Riparian grazing management, Provide filter strips along streams	A few improvements could be achieved in upper Cherry Creek but riparian management appears to be good to fair along the upper/middle of the watershed. Grazing related impacts were noted in the area just downstream of public lands on private property. There may also be some effects from irrigation infrastructure. Green line degradation in the floodplain and the loss of riparian habitat is much more prevalent in the lowest segments of the watershed. Much of grazing effects occur on private lands.
			2	Eroding Banks needing sustainable riparian zone vegetative condition	Riparian grazing management, Riparian willow vegetation restoration	

Table 6-1. Summary of Sediment Load Reductions and Ranked Restoration Strategy by Watershed

Name of Water body	Current Sediment Loads (tons per year)	TMDL Sediment Load Reduction (% of total load)	Source and Restoration Rank	Ranked Controllable Sources	Ranked BMP Type	Spatial concerns
Fish Creek	3,264	36%	1	Eroding Banks needing sustainable riparian zone vegetative condition	Riparian grazing management, Riparian willow vegetation restoration in grazed and cropped areas	Eroding banks with insufficient riparian cover occur along significant but intermittent reaches of both the lower and upper portions of the creek. Some riparian areas are managed well and others need riparian restoration work. Riparian health appears to be fair in upper portions of the watershed with a few heavily impacted areas of poor health. The lower portions of the watershed exhibit Good, Fair and Poor riparian condition and impacts are primarily associated with grazing and haying within the riparian zone. In the upper portions of the watershed effects from placer mining including channelization and degraded riparian health are apparent. Spatial considerations are provided in Appendix E & G
			2	Upland Sediment from grazing and hay production	Riparian grazing and cropping management, Provide filter strips along streams	
			3	Unpaved roads	Road maintenance and runoff BMPS	Road maintenance should occur on many unpaved road crossings. Spatial considerations are provided in Appendix C & F.

Table 6-1. Summary of Sediment Load Reductions and Ranked Restoration Strategy by Watershed

Name of Water body	Current Sediment Loads (tons per year)	TMDL Sediment Load Reduction (% of total load)	Source and Restoration Rank	Ranked Controllable Sources	Ranked BMP Type	Spatial concerns
Hells Canyon Creek	1,473	36%	1	Eroding Banks needing sustainable riparian zone vegetative condition	Riparian grazing management, Riparian willow vegetation restoration in grazed and cropped areas	Eroding banks with insufficient riparian cover occur along significant but intermittent reaches of both the lower and upper portions of the creek. Some riparian areas are managed well and others need riparian restoration work. Riparian health appears to be fair in upper portions of the watershed with a few heavily impacted areas of poor health. The lower portions of the watershed exhibit Good, Fair and Poor riparian condition and impacts are primarily associated with grazing and haying within the riparian zone. In the upper portions of the watershed effects from placer mining including channelization and degraded riparian health are apparent. Spatial considerations are provided in Appendix E & G
			2	Upland Sediment from grazing and hay production	Riparian grazing and cropping management, Provide filter strips along streams	
			3	Unpaved roads	Road maintenance and runoff BMPS	Road maintenance should occur on many unpaved road crossings. Spatial considerations are provided in Appendix C & F.

Table 6-1. Summary of Sediment Load Reductions and Ranked Restoration Strategy by Watershed

Name of Water body	Current Sediment Loads (tons per year)	TMDL Sediment Load Reduction (% of total load)	Source and Restoration Rank	Ranked Controllable Sources	Ranked BMP Type	Spatial concerns
Little Pipestone Creek	5,821	41%	1	Eroding Banks needing sustainable riparian zone vegetative condition,	Riparian grazing management, Riparian willow vegetation restoration, Move haying from riparian green line	Eroding banks with insufficient riparian cover occur along significant but intermittent reaches of both the lower and upper portions of the creek. Some riparian areas are managed well and others need riparian restoration work. Riparian health appears to be fair in upper portions of the watershed while health markedly declines to a mix of fair and poor in the lower portions. Tributaries should also addressed to reduce sediment loads to Little Pipestone Creek. In both the lower and upper portions of the watershed effects from Irrigation infrastructure are apparent. Spatial considerations are provided in Appendix E & G
			2	Upland Sediment from grazing,	Riparian grazing management, Provide filter strips along streams	
			3	Paved and Unpaved roads	Road maintenance and runoff BMPS	Road maintenance should occur on unpaved road crossings and road wash sources. Spatial considerations are provided in Appendix C & F.
Whitetail Creek	9.569	45%	1	Eroding Banks needing sustainable riparian zone vegetative condition,	Riparian grazing management, Riparian willow vegetation restoration, Move haying from riparian green line	Eroding banks with insufficient riparian cover occur along significant but intermittent reaches of both the upper and lower portions of the creek. Some riparian areas are managed well and others need riparian restoration work. Riparian health appears to be fair in upper portions of the watershed while health markedly declines to poor in the lower portions. Tributaries should also be addressed to reduce sediment loads to Little Pipestone Creek. In both the lower and upper portions of the watershed effects from Irrigation infrastructure are apparent. Spatial considerations are provided in Appendix F & G
			2	Upland Sediment from grazing,	Riparian grazing management, Provide filter strips along streams	

6.3.1.1 Big Pipestone Creek

The current sediment load for Big Pipestone Creek is estimated at 6,612 tons per year; the TMDL sediment load reduction is 57% (**Section 5.7.1**). Restoration strategies for this watershed vary from a most-aggressive approach involving significant channel work to simply continuing with existing BMPs (**Table 6-1**).

Because of the obvious differences in land use, cover, ownership, and pollutant source types, for the purposes of this section, Big Pipestone Creek was broken into two restoration segments: Upper Big Pipestone Creek, extending from the Delmoe Lake outlet to the I-90 crossing, and Lower Big Pipestone Creek, extending from the I-90 crossing downstream to the confluence with the Jefferson River.

Within the upper portion of Big Pipestone Creek land ownership is primarily under the U.S. Forest Service (USFS) and the Bureau of Land Management (BLM). The dominant riparian cover along Big Pipestone Creek above I-90 is mixed coniferous forest with upland shrubs (**Appendix C, Figure 2-9**). The relative health category assigned to all of the upper reaches was: “Fair. Vegetation appears healthy but some disturbance is present.” (**Appendix E, Figure E-3**). Many pollution sources along Big Pipestone Creek above I-90 were related to operations at Delmoe Lake Dam and to unpaved roads and trails. Sediment from paved and unpaved roads, as well as sediment from ATV/motorcycle trails, is impacting upper Big Pipestone Creek. Restoration priorities in the upper portions of the watershed should focus primarily on road and trail sources and secondarily upland grazing and riparian management.

A French drain on Big Pipestone Creek at the I-90 road crossing separates the upper and lower portions of the watershed. The drain traps many of the fine sediments transported by the creek as indicated by a large depositional zone extending well above the culvert (north side of I-90). It is likely that this trap prevents substantial amounts of fine sediments from reaching the valley bottom segment of the creek and affects the sediment transport capacity of the creek below I-90. The creek must flow under I-90, subsurface, to continue on course. Should the drain be brought to the proper grade for surface flow, it is possible that more fine sediments would be transported and deposited to the valley reaches. Thus, restoration efforts should include more research into addressing the incorrectly aligned drain and future maintenance. Before action is taken to remove or change the connectivity of the upper and lower portions of the watershed, it is recommended that Montana Fish, Wildlife and Parks be contacted regarding Westslope cutthroat trout populations and whether the existing barrier is protecting some populations.

Land ownership is primarily private in the lower portions of Big Pipestone Creek. The dominant riparian cover along Big Pipestone Creek below I-90 had been herbaceous; however, agricultural grasses and forbs are now grown in the riparian corridor and almost all woody vegetation is absent (**Appendix C, Figure 2-10**). The typical health category describing the various reaches of the stream in the lower valley was “Fair. Vegetation appears healthy, but some disturbance is present” and “Poor” due to notable disturbance (**Appendix E, Figure E-3**).

Many pollution sources along lower Big Pipestone Creek come from agricultural operations in the riparian zone. During the field source assessment, grazing impacts (trampled banks, over-

widened channel, channel braids) were observed in all of the surveyed reaches. In addition, channel alterations for irrigation diversions were observed in many places. In general, stream condition deteriorates heading downstream to the mouth. Just above Whitehall, the Jefferson Ditch water has caused severe incisement of the stream channel, which has subsequently headcut upstream due to poor riparian vegetation conditions. Restoration priorities in the lower watershed should focus primarily on reducing bank erosion and managing riparian areas, including impacts from grazing and hay production. Irrigation effects on bank erosion, stream channelization, and incisement are significant; however, the cost of restoring such structures and associated channel impacts are often high. Thus, with regards to irrigation infrastructure, restoration planning should include a cost-benefit analysis to help guide prioritization in addressing these problems.

6.3.1.2 Cherry Creek

The current sediment load for Cherry Creek is estimated at 2,759 (see **Table 6-1**) tons per year; the TMDL sediment load reduction is 43% (**Section 5.7.2**). Restoration strategies for this watershed vary from riparian grazing management to simply continuing existing BMPs (**Table 6-1**)

Landownership in Cherry Creek is primarily private, except for a small portion of USFS land in the headwaters. The dominant riparian cover in the headwaters was mixed coniferous forest with upland shrubs (**Appendix C, Figure 2-14**). The relative riparian health category assigned to this reach was "Excellent. Vegetation appears to be vigorous, with various age classes present (little or no disturbance)" (**Appendix E, Figure E-3**). No significant sources of sediment were noted in the headwaters section.

The dominant riparian cover along the canyon sections of Cherry Creek was mixed coniferous, with some areas of dominantly deciduous forest (**Appendix C, Figure 2-14**). The relative health category was "Fair. Vegetation appears healthy, but some disturbance is present" (**Appendix, E Figure E-3**). In the canyon area—just downstream of public lands—on private lands streambank erosion and significant impacts to the riparian vegetation were noted. For this area restoration activities should primarily focus on improving the health of the vegetated riparian buffer by implementing grazing BMPs.

The dominant riparian cover along the alluvial fan portion of Cherry Creek was herbaceous, where grasses or forbs were being grown into the riparian zone; almost no woody vegetation was present (**Appendix C, Figure 2-14**). The relative health category was "Fair" to "Poor" due to notable disturbance (**Appendix E, Figure E-3**). In addition to minor impacts to the stream from riparian grazing, agricultural practices and development within the floodplain have significantly reduced the riparian buffering capacity. Restoration priorities within the alluvial fan of Cherry Creek should primarily focus on protecting and enhancing the vegetated riparian buffer around agricultural areas and mitigating the impacts of development in the floodplain.

6.3.1.3 Fish Creek

The current sediment load for Fish Creek is estimated at 3,264 tons per year; the TMDL sediment load reduction is 36% (**Section 5.7.3**). Restoration strategies for this watershed vary

from a most-aggressive approach involving significant channel work to simply continuing existing BMPs (**Table 6-1**).

Because of the differences in land use, cover, and pollutant source types, for the purposes of this section Fish Creek was broken into two restoration segments: Upper Fish Creek, extending from the headwaters in the highland mountains to the Jefferson Valley floor, and Lower Fish Creek, extending from the lower boundary of the upper segment downstream to its confluence with the Jefferson Canal.

Within the upper portion of Fish Creek, land ownership is primarily USFS, BLM, and private. The dominant riparian cover along upper Fish Creek, within the Highland Mountains, is mixed coniferous forest with upland shrubs (**Appendix C, Figure 2-21**). Healthy riparian vegetation is virtually absent in some reaches and could probably be attributed to many sources (grazing, placer mining, roads). The relative health categories in the upper reaches vary from “Excellent” to “Poor,” depending on the amount of visible disturbance (**Appendix E, Figure E-3**). In the headwaters portion of Upper Fish Creek various sources of sediment were observed and relate to riparian grazing, unpaved roads, and historic mining. The effects of placer mining and channelization have modified the channel form and altered riparian vegetation. Sediment from unpaved roads and bank erosion (stemming from road encroachment) were observed at numerous locations on both public and private lands. Silvicultural activities were also noted as a potential source; however, harmful effects from these activities were not observed in the field. Restoration priorities for the Upper Fish Creek watershed should focus primarily on revegetating the impacted riparian buffer by managing grazing and mitigating historic mining impacts. Mine mitigation and cleanup often take extensive channel work at an exorbitant expense; therefore, more research is recommended to determine the costs and benefits. The second restoration strategy should focus on controlling erosion from obvious unpaved road delivery sites.

The dominant riparian plants along Lower Fish Creek in the Jefferson valley were wetland species (**Appendix C, Figure 2-22**). The relative health category of most of the valley reaches was “Fair”; however, reaches of “Excellent” and “Poor” are also apparent, depending on the amount of visible disturbance (**Appendix E ,Figure E-3**). Within Lower Fish Creek, sediment sources came from agricultural operations and related bank erosion and alterations to riparian vegetation. The lowermost portions of the stream are chronically dewatered, and discussions with local landowners revealed that dewatering has isolated a population of Westslope cutthroat trout in the upper portions of the watershed. Restoration priorities within Lower Fish Creek should focus on revegetating degraded riparian environments to reduce bank erosion and trap sediment from upland agricultural sources.

6.3.1.4 Hells Canyon Creek

The current sediment load for Hells Canyon Creek is estimated at 1,473 tons per year; the TMDL sediment load reduction is 36% (**Section 5.7.4**). Restoration strategies for this watershed vary from a most-aggressive approach involving eroding bank restoration to simply continuing existing BMPs (**Table 6-1**).

Landownership within Hells Canyon Creek is predominantly USFS and BLM, with a small track of private land adjacent to the stream near the mouth. Riparian cover along Hells Canyon Creek alternated between mixed coniferous forest with upland shrubs (confined valley bottom areas), wetlands (less confined valley bottom areas), and mixed coniferous with some areas of dominantly deciduous forests located in the alluvial fan portion of the watershed (**Appendix C, Figure 2-32**). The relative health categories of reaches varied between "Excellent" and "Fair." One reach was delineated as having "Poor" riparian health due to bare ground associated with a road failure that occurred sometime after 1983 (**Appendix E, Figure E-3**). Within Hells Canyon Creek, sources of sediment include bank erosion, riparian grazing, and unpaved road /recreation-related sources. One stream reach within the Hell's Canyon Creek Riparian Project area is fenced off from grazing. Field observations noted a significant reduction in vegetative health and streambank condition outside of the project area. Restoration strategies should focus primarily on revegetating degraded riparian zones to reduce bank erosion and capture sediment from grazing activities. Additional measures include evaluating bank stabilization needs for the road failure noted above and reducing sediment from unpaved roads and trails.

6.3.1.5 Little Pipestone Creek

The current sediment load for Little Pipestone Creek is estimated at 5,821 tons per year; the TMDL sediment load reduction is 41% (**Section 5.7.5**). Restoration strategies vary from a most-aggressive approach involving eroding bank stabilization to simply continuing existing BMPs (**Table 6-1**).

Because of the differences in land use, cover, and pollutant source types, for the purposes of this section, Little Pipestone Creek was broken into two restoration segments: Upper Little Pipestone Creek, extending from the headwaters in the highland mountains to the Jefferson Valley, and Lower Little Pipestone Creek, extending from the lower boundary of the upper segment downstream to its confluence with Big Pipestone Creek.

Landownership within Upper Little Pipestone Creek is mostly private with a portion of USFS land in the headwaters. Riparian cover is variable (**Appendix C, Figure 2-36**). The relative health category of the riparian vegetation regressed from "Excellent" to "Poor" heading downstream (**Appendix E, Figure E-3**). Areas of poor riparian health in Upper Little Pipestone are related primarily to highway encroachment and near-stream grazing. Watershed sediment sources come from roads, rill and gully erosion, and bank erosion from road encroachment. Some grazing-related sources were present with impacts to riparian health. Restoration priorities should focus primarily on road and trail sources and secondarily upland grazing and riparian management.

Landownership within Lower Little Pipestone Creek is completely private. Riparian vegetative cover along Lower Little Pipestone Creek ranges from predominantly deciduous, to wetlands, to herbaceous (**Appendix C, Figure 2-37**). The relative health category of the lower reaches regressed from "Fair" to "Poor" heading downstream (**Appendix E, Figure E-3**). Areas of "Poor" riparian health were related to agricultural operations, including hay production and near-stream grazing. Bank erosion, channel incisement, riparian degradation, and grazing-related sources were observed in the valley reaches surveyed. Sediment sources came from agricultural

operations and their effects on bank erosion and riparian vegetation. Restoration priorities should focus on revegetating degraded riparian environments to reduce bank erosion and trap sediment from upland agricultural sources.

6.3.1.6 Whitetail Creek

The current sediment load for Whitetail Creek is estimated at 9,569 tons per year; the TMDL sediment load reduction is 45% (**Section 5.7.6**). Restoration strategies for this watershed vary from a most-aggressive approach involving significant riparian improvements to simply continuing existing BMPs (**Table 6-1**).

Because of the differences in land use, cover, and pollutant source types, for the purposes of this section, Whitetail Creek was broken into two restoration segments: Upper Whitetail Creek, extending from the headwaters to the Jefferson valley, and Lower Whitetail Creek, extending from the lower boundary of the upper segment downstream to its confluence with the Jefferson Slough, a former channel of the Jefferson River.

Landownership in Upper Whitetail Creek is primarily USFS with two small tracts managed by BLM and the state. Riparian cover is mixed coniferous forest with upland shrubs, wetlands (less confined valley bottom areas), and deciduous forest (**Appendix C, Figure 2-42**). Buffer widths were generally limited by valley bottom width and the availability of moisture. The relative health categories assigned to all of the upper reaches was either “Excellent” or “Fair,” depending on visible disturbance. Most of the pollution sources observed in the field along Upper Whitetail Creek were related to riparian grazing, its effects on bank erosion and riparian health, and unpaved roads and/or trail crossings.

Landownership is predominately private. Riparian cover along Lower Whitetail Creek consists of herbaceous and wetland types (**Appendix C, Figure 2-43**). The relative health category of most of the lower reaches was “Poor” primarily due to agricultural activities, including irrigated crops and near-stream grazing (**Appendix E, Figure E-3**). Though small in area, residential development in and around the town of Whitehall has also negatively affected riparian health. During the field source assessment, grazing impacts were observed in all of the surveyed reaches. The sources observed varied locally and according to the property owner’s use of the land, such as confined feedlots, removal of riparian vegetation, and small grazing pastures.

Restoration strategies in both the upper and lower segments of Whitetail Creek should primarily focus on revegetating degraded riparian environments to reduce bank erosion and trap sediment from upland agricultural sources.

6.4 Restoration Approaches by Source

For the major sources of human-caused pollutant loads in the Upper Jefferson watershed, general management recommendations are outlined below. Applying ongoing BMPs is the core of the sediment reduction strategy but only forms a part of the restoration strategy. Restoration might also address other current pollution-causing uses and management practices. In some cases, efforts beyond implementing new BMPs may be required to address key sediment sources. In

these cases, BMPs are usually identified as a first effort followed by an adaptive management approach to determine if further restoration activities are necessary to achieve water quality standards. Monitoring is also an important part of the restoration process. Monitoring recommendations are outlined in **Section 7**.

6.4.1 General Grazing Management BMP Recommendations

Improving riparian habitat, streambank erosion, and channel condition by implementing grazing BMPs are documented in the literature (Mosley et al., 1997). The restoration strategy for reducing impacts of grazing on water quality and riparian and channel condition includes implementing multiple BMPs prescribed on a site-specific basis. BMPs are most effective as part of a management strategy that focuses on critical areas within the watershed, i.e. those areas contributing the largest pollutant loads or sites that are susceptible to impacts from grazing. These riparian BMPs promote properly functioning riparian communities and reduce damage to streambanks. BMPs include managing the timing, intensity, and duration of grazing; establishing and maintaining preferred deep-rooted woody cover; developing infrastructure such as fences and hardened crossings; and managing feeding areas, salt licks, and water availability. In combination, these integrated approaches promote vegetative vigor and protect near-stream soils. BMPs should be determined on a site-specific basis that incorporates the landowner's production needs and associated logistics, while promoting sediment/riparian allocations and targets.

Some general grazing management recommendations and BMPs to address grazing sources of pollutants and pollution are listed below (**Table 6-2**). Implementing BMPs is voluntary. However, other planning partners, including the Jefferson Watershed Coordination Council and NRCS, will be instrumental in involving individual landowners, developing site-specific plans, and obtaining funding.

Table 6-2: General Grazing BMPs and Management Techniques (from NRCS 2001 and DNRC 1999).

BMP and Management Techniques	Pollutants Addressed
Design a grazing management plan and determine the intensity, frequency, duration, and season of grazing to promote desirable plant communities and productivity of key forage species. In this case, native riparian species.	Sediment, temperature, nutrients
Encourage the growth of woody species (willow, alder, etc.) along the streambank, which will limit animal access to the stream and provide root support to the bank.	Sediment, nutrients, temperature
Establish riparian buffer strips of sufficient width and plant composition to filter and take up nutrients and sediment from concentrated animal feeding operations.	Sediment, nutrients,
Create riparian buffer area protection grazing exclosures through fencing.	Sediment, temperature, nutrients
Maintain adequate vegetative cover to prevent accelerated soil erosion, protect streambanks, and filter sediments. Set target grazing use levels to maintain both herbaceous and woody plants.	Sediment

Table 6-2: General Grazing BMPs and Management Techniques (from NRCS 2001 and DNRC 1999).

BMP and Management Techniques	Pollutants Addressed
Ensure adequate residual vegetative cover and regrowth and rest periods. Periodically rest or defer riparian pastures during the critical growth period of plant species.	Sediment, nutrients
Alternate a location's season of use from year to year. Early spring use can cause trampling and compaction damage when soils and streambanks are wet. If possible, develop riparian pastures to be managed as a separate unit through fencing.	Sediment, nutrients
Provide off-site, high quality water sources.	Sediment, nutrients
Periodically rotate feed and mineral sites and generally keep them in uplands.	Sediment, nutrients
Place salt and minerals in uplands, away from water sources (ideally ¼ mile from water to encourage upland grazing).	Sediment, nutrients, temperature
Monitor livestock forage use and adjust strategy accordingly.	Sediment, nutrients, temperature
Create hardened stream crossings.	Sediment

6.4.1.1 Animal Feeding Operations

Because they generate significant amounts of manure and wastewater, animal feeding operations (AFOs) can pose a number of risks to water quality and public health. To minimize the impacts, as well as spreading animal waste on land, the U.S. Department of Agriculture (USDA) and Environmental Protection Agency (EPA) released the Unified National Strategy for AFOs in 1999 (NRCS 2005). It encourages AFO operators of any size to voluntarily develop and implement site specific Comprehensive Nutrient Management Plans (CNMPs) by 2009. The CNMP document details manure storage and handling systems, surface runoff control measures, mortality management, chemical handling, manure application rates, schedules to meet crop nutrient needs, land management practices, and other options for manure disposal. An AFO that exhibits certain criteria is referred to as Concentrated Animal Feeding Operation (CAFO) and, in addition, may be required to obtain a Montana Pollution Discharge Elimination System (MPDES) permit as a point source. Montana's AFO compliance strategy is based on federal law and has voluntary as well as regulatory components. If voluntary efforts can eliminate discharges to state waters, no direct regulation is necessary through a permit in some cases. Operators of AFOs may take advantage of effective low cost practices to reduce potential runoff to state waters, which additionally increase property values and productivity. Properly installed vegetative filter strips, in conjunction with other practices to reduce waste loads and runoff volume, are effective at trapping sediment and reducing transport of nutrients and pathogens to surface waters; removal rates approach 90% (NRCS 2005). Other installations might include clean water diversions, roof gutters, berms, sediment traps, fencing, structures for temporary manure storage, shaping, and grading. Animal health and productivity also benefits when clean alternative water sources are installed to prevent contamination of surface water. Studies have shown benefits in red meat and milk production of 10% to 20% when good quality drinking water is substituted for contaminated surface water.

Financial and technical assistance for achieving voluntary AFO and CAFO compliance are available from conservation districts and NRCS field offices. Voluntary participation may help prevent a more rigid regulatory program from being implemented by the Montana Nonpoint Source Management Plan for Montana livestock operators in the future.

Further information is available from DEQ's Web site: http://www.deq.mt.gov/wqinfo/mpdes/cafo.asp.

Montana's NPS pollution control strategies for addressing AFOs are summarized below:

- Work with producers to prevent NPS pollution from AFOs.
- Promote use of State Revolving Fund for implementing AFO BMPs.
- Collaborate with MSU Extension Service, NRCS, and agriculture organizations in providing resources and training in whole farm planning to farmers, ranchers, conservation districts, watershed groups, and other resource agencies.
- Encourage inspectors to refer farmers and ranchers with potential nonpoint source discharges to DEQ watershed protection staff for assistance with locating funding sources and grant opportunities for BMPs that meet their needs. (This is in addition to funds available through NRCS and the Farm Bill).
- Develop early intervention of education and outreach programs for small farms and ranches that have the potential to discharge nonpoint source pollutants from animal management activities. This includes assistance from DEQ Permitting Division (internal), as well as external entities (DNRC, local watershed groups, conservation districts, MSU Extension).

6.4.1.2 Riparian Vegetation Restoration

Reduced riparian vegetative cover is a principal cause of water quality and habitat degradation in the Upper Jefferson watershed. Although implementing grazing, irrigation, and agricultural BMPs would promote recovery of riparian communities, the severity of the impairment suggests that natural recovery rates may be insufficient in many reaches to meet conservation goals in a timely manner to protect native fish populations and aquatic life. All areas that are actively restored with vegetation must have a reasonable approach to protecting the invested effort from further degradation from livestock or hay production.

Riparian planting will be necessary to achieve some stream targets within a desirable period. Factors influencing appropriate riparian restoration would include the severity of degradation, site-potential for various species, and the availability of local sources as transplant materials. In general, riparian plantings would promote the establishment of functioning stands of native species (grasses and willows). The following recommended restoration measures would help stabilize the soil, decrease sediment reaching the streams, and increase nutrient absorption from overland runoff.

- Harvest and transplant locally available sod mats with dense root mass to immediately promote bank stability and capture nutrients and sediments.

- Transplant mature shrubs, particularly willows (*Salix* sp.), to rapidly restore instream habitat and water quality by providing overhead cover and stream shading, as well as uptake of nutrients.
- Seed with native graminoids (grasses and sedges) and forbs, a low cost activity where lower bank shear stresses would be unlikely to cause erosion.
- Plant willows by "sprigging" to expedite vegetative recovery; sprigging involves clipping willow shoots from nearby sources and transplanting them in the vicinity where needed.

6.4.1.3 Streambank/Floodplain Restoration BMPs

Bank erosion from willow removal and livestock grazing are a major source of sediment. Reductions in streamside willows appeared to have resulted in some overly wide and shallow channel segments. Over-widened channels can cause fine sediment to accumulate in pools because of reduced sediment transport efficiencies. Thus, stream channels might have fewer or lower quality pools with increased sediments. Over-widened channels increase sediment concentrations and water temperatures, reducing aquatic habitat quality.

These general restoration activities focus on enhancing suitable instream habitat for native fishes and speeding up recovery for stream channels, bank erosion, and riparian vegetation shading. They would assist in meeting sediment TMDL targets in stream reaches that have historically been heavily altered by grazing, channeling, mining, transportation, or haying. Actual restoration activities would be determined on a site-by-site basis and depend on the relationships among shrub cover, width-to-depth ratios, eroding banks, and pool frequency.

6.4.2 Unpaved Roads BMPs

Road sediment reduction represents the estimated sediment load that would remain once all contributing road treads, cut slopes, and fill slopes were reduced to the maximum of 200 feet. These measurements were selected as an example to illustrate the potential for sediment reduction by using BMPs and are not a formal goal at every crossing. For example, many road crossings in mountainous settings can easily have a contributing length shorter than 200 feet, while others may not be able to meet a 200-foot milestone. Reducing sediment loading from the road system as called for in the TMDLs may occur through a variety of methods at the discretion of local land managers and restoration specialists.

Assessments should occur for roads within watersheds that have timber harvesting or other major land management operations. The information gathered will give timely feedback to land managers about the impact their activities could have on water quality and achieving TMDL targets and allocations. This feedback mechanism is intended to keep sediment load calculations current and avoid new road impacts that go undetected for a long periods.

6.4.3 Sediment Loading Due to Gully Wash and Rill Erosion along Interstate 90

The input and transport of gully wash and rill erosion was assessed along Homestake Creek, tributary to Big Pipestone Creek, adjacent to I-90. The assessment was presented in a thesis

submitted to Montana Tech by student Aaron Berger and titled *Hydrology, Water Quality, and Sediment transport Rates in the Pipestone Creek Watershed, Jefferson County, Montana* (Berger 2004). It attempted to semi-quantify the volume of sediment produced from sources associated with I-90. Berger estimated that the approximate volume of sediment entering Homestake Creek from I-90 was roughly 500 cubic feet, or 21 tons (assuming a bulk density of 1.44 tons/cubic yard). However, due to the high rates of bedload transport in the stream, it is likely that this total was significantly underestimated. Berger also noted that the sediment inputs were dominated by four large sources that were traced to uncontrolled runoff from I-90 and subsequent gullying and rill erosion of steep hillslopes leading down to Homestake Creek.

In the TMDLs and allocations that follow, a 10% reduction in human-caused sediment load from I-90 sources is proposed. The Montana Department of Transportation will explore alternatives for diverting road runoff from sensitive areas and capturing sediment. Additionally, BMPs may be used to prevent road materials from entering Homestake Creek, such as gully wash, rill erosion, and road traction sanding. BMPs may include vegetation buffers, routing flows away from streams, and the creation of sediment catching structures. Loading from gully wash and rill erosion will be considered in developing sediment loads, allocations, and potential reductions. Road traction sanding also has the potential to produce a sediment load. Though not included in this allocation strategy, road traction sanding should be evaluated through adaptive management and monitoring.

6.4.4 Forestry and Timber Harvest

Currently, timber harvest is not significantly affecting sediment production in the Upper Jefferson TPA, but harvesting will likely continue in the future within the national forest and on private land. Future harvest activities should be conducted by all landowners and contractors according to Forestry BMPs for Montana (MSU Extension Service 2001) and the Montana SMZ Law (77-5-301 through 307 MCA). The Montana Forestry BMPs cover timber harvesting and site preparation, harvest design, other harvesting activities, slash treatment and site preparation, winter logging, and hazardous substances. While the SMZ Law is intended to guide commercial timber harvesting activities in streamside areas (i.e., within 50 feet of a water body), the riparian protection principles behind the law can be applied to numerous land management activities (i.e., timber harvest for personal use, agriculture, development). Before harvesting on private land, landowners or operators are required to notify the Montana DNRC, who are responsible for assisting landowners with BMPs and monitoring their effectiveness. The Montana Logging Association and DNRC offer regular forestry BMP training sessions for private landowners.

Timber harvest should not increase the peak water yield by more than 10%. If a natural disturbance, such as a forest fire, increases peak water yield, the increase should be accounted for as part of timber harvest management.

6.4.5 Fire Suppression, Conifer Encroachment, Water Yield and Soil Erosion

The anthropogenic management of the forested uplands within the Upper Jefferson River watershed has substantially affected the structure of the forest community and its interrelations with riparian function, water yield and soil erosion. There exists considerable debate about both the extent and nature of human-caused changes in the forest landscape, and the need and means to address those changes. Though not explicitly addressed within the TMDL and allocations section of this document, this discussion is included as an additional tool for the prioritization of riparian restoration strategies. In focusing on issues relating to forest alteration and restoration in central western Montana, this section is a modest attempt to identify how long term management of fire suppression in forested uplands has the potential to affect water yields and sediment production. In addition this section introduces some basic restoration strategies that could be implemented to offset such affects.

Many upland portions of the Upper Jefferson watershed are experiencing a substantial increase in the density of conifer species. Rangeland grazing and fire suppression has contributed to the increase in conifer woodlands and a reduction in open grasslands. The density of trees, and the aerial extent of these communities, is evidenced by historic photos and the age structure of these woodlands. These trees effectively out-compete other shrub and herbaceous species resulting in decreased and/or inconsistent water yields, and increased soil erosion. The deep, tap roots of conifers are much less effective in retaining soil than the fibrous, surface roots of herbaceous species. As conifer woodlands continue to increase, and as the rill and gully erosion areas continue to expand and become connected, these communities will be an increasing upland source of sediment into tributary streams of the Upper Jefferson River watershed, particularly in large storm events that generate overland flow.

In addition to upland areas, riparian communities along stream corridors in many montane rangeland watersheds have been disrupted by encroaching conifers which can cause changes in riparian corridor functions. Native riparian vegetation, such as aspen overstory, and herbaceous and shrub understory, provides crucial sediment filtering and channel protection that is significantly reduced when conifers come to dominate riparian vegetation. Studies have shown that soil loss or erosion can be elevated by up to 10 times in juniper-encroached areas in comparison with native vegetation providing natural vegetative protection (DeBoodt, et. al., 2005). In addition to effects on soil erosivity, conifer encroachment effects watershed function through the loss of plant and animal diversity, as well as hydrologic changes such as reduced stream flow.

The potential hydrologic effects conifer encroachment can be significant in small first order intermittent or ephemeral drainages. Successional conifer encroachment in drainages can cease water yield during the summer from seeps and springs in the upper headwaters regions of watersheds. A conifer tree has a higher transpiration rate than a similar aspen tree; hence more water is drawn from the soil from a conifer stand than aspen stand. This reduction in flow can reduce the overall acreage available for upland grazing and may focus grazing into smaller ranges, posing a potential greater threat on those waterbodies with greater flow. Such instances could greatly effect sediment production in these streams by reducing riparian buffering and increasing bank erosion via trampling. Furthermore, the lack of aspen and flowing water has the

potential to eliminate the most suitable beaver habitat in the area. Beavers are discussed in the next section.

Of the approximately 470,000 acres in the upper Jefferson watershed, approximately 3.1 percent (14,700 acres) of the watershed is classified as riparian vegetation, and conifers (mostly junipers) dominate this riparian vegetation on approximately 22 percent (3,300 acres) of the watersheds' riparian acres.

While knowledge of historical conditions will be useful, even essential, in guiding restoration efforts, attempts to strictly recreate conditions of the past will often be neither desirable nor feasible. Knowledge of historic conditions can help clarify the types and extent of changes that have occurred in ecosystems and help inform the identification of management objectives and restoration priorities. However, climates are now different than at any historic time, and will be different in the future (Millar and Woolfenden 1999). Species have been irrevocably added and subtracted, and the modern human imprint cannot be entirely eliminated. While past fire regimes may be more accurately estimated than forest structure and composition, as Agee (1998b) points out, "the natural fire regimes of the past are not the regimes of the present, nor will they be the regimes of the future." Nonetheless, careful determinations of past conditions can be an essential part of deciding what needs to be done now and in the future. Restoration planning needs to recognize that historic and/or "natural" conditions may or may not be appropriate for today or successfully maintained.

In the upper Jefferson area, exclusion of periodic intense fires has supported conifer expansion and encroachment into riparian areas. Ongoing livestock and wildlife grazing have enhanced the effects of this invasion. Effective watershed restoration tools to restore functioning native overstory and understory vegetation in riparian corridors include: 1. moderate intensity fires (eliminating most conifers and stimulate native vegetation regrowth), 2. conifer removal (chainsawing conifers, leaving tree slash to protect bare ground, and shelter regrowth), and 3. conifer reduction (light fire/slashing followed by planting of native vegetation). It should be noted that all the restoration tools above should take a proactive approach to controlling other invasive non-native weeds.

Prior to the implementation of such restoration activities within the upper Jefferson watershed further studies will need to be done to evaluate the tradeoffs of riparian restoration via harvest and/or prescribed fire. In addition, in some areas conifers represent the natural occurring dominant riparian vegetation. In these areas conifers are critical to shade and stream geomorphology, and are protected via the Montana's Stream Side Zone law. Therefore, the restoration strategies presented here only apply to those areas that under natural conditions would be different and in no way advocates riparian harvest in areas where mature conifers are the natural stream side vegetation (although prescribed burning in such areas may be appropriate in a case by case basis).

Every effort should be made to apply these tools thoughtfully, in ways and in locations where they will have the highest prospects for success and the lowest likelihood of unintended consequences. Based on current knowledge, it appears that the most credible efforts will:

- Be part of comprehensive ecosystem and watershed restoration that addresses roads, livestock grazing, invasive exotic species, off-road vehicles, etc;
- Consider landscape context, including watershed condition and populations, as well as habitats, of fish and wildlife;
- Address causes of degradation, not just symptoms;
- Provide timber only as a by-product of primary restoration objectives;
- Avoid construction of new roads;

6.4.6 Beaver Populations and Sediment Yields

Historic heavy trapping of beavers has likely had a dramatic effect on sediment yields in the watershed. Before the removal of beavers, many streams had a series of catchments that moderated flow, with smaller unincised multiple channels and frequent flooding. Now many streams have an increased channel capacity, with incised wider channels and are no longer connected to the floodplain. This results in more bank erosion because high flows scour streambanks to a greater extent instead of flowing onto the floodplain. Parker (1986, as cited in Olson and Hubert, 1994) reported water below beaver complexes had 50% to 77% lower total suspended solids (TSS) than water above complexes.

Beavers are still trapped in the Jefferson watershed. Trapping is often in response to complaints about detrimental beaver activity in lower reaches of tributaries or irrigation ditches, where they plug culverts or ditches and cut down trees that are valued for shade. Trappers still remove beavers from headwaters streams, as well, for recreation and pelts. Beavers are re-establishing themselves where habitat is adequate, but much of the area that potentially could support beaver populations currently does not have adequate woody riparian vegetation to support beavers.

Management of headwaters areas should include improving beaver habitat. Long-term management could include maintenance of headwaters protection areas and managing beaver populations re-established in areas currently lacking the beaver complexes to trap sediment, reduce peak flows, and increase summer low flows.

6.5 Watershed Restoration Summary

The most important restoration efforts for implementation in tributary streams of the Upper Jefferson watershed will be to protect, restore, and enhance riparian vegetation. Restoring riparian areas will provide the greatest sediment load reductions. A tiered approach for restoring stream channels and adjacent riparian vegetation should consider the existing conditions of the stream channel and adjacent vegetation. In non-conifer dominated areas, the restoration goals should focus on restoring natural shrub cover on streambanks to reference levels that are provided by the sediment TMDL riparian vegetation targets. In areas with little to no shrub vegetation within non-conifer dominated riparian zones, active natural shrub reintroduction should occur. In areas where stream channels are unnaturally stable or streambanks are eroding excessively, active restoration approaches, such as channel design, bank sloping, seeding, and shrub planting, may be needed.

All riparian areas should be protected against excessive hoof sheer, over-grazing, and especially over-browsing. In many cases where riparian areas are heavily impacted, protection may need a several years of rest with careful rotation schedules thereafter. In areas meeting riparian, stream channel, and other targets, these protections should continue with active grazing and hay management. Active riparian grazing management is important for long-term health of riparian zones. Management following restoration in these zones should include keeping browsing to a minimum once shrub health has increased. These areas should be used during specific seasons that promote grazing and not browsing. Grazing of riparian areas should occur in a shorter time window and only when sufficient forage is available. Grazing systems should be dynamic and based upon measures of browsing, hoof sheer, and stubble height only after sufficient shrubs have been allowed to recover. Weed management should also be a dynamic component of managing riparian areas as they recover.

SECTION 7.0
MONITORING STRATEGY AND ADAPTIVE MANAGEMENT

7.1 Introduction

The monitoring strategy discussed in this section is an important component of watershed restoration, a requirement of TMDL development under Montana's TMDL law, and the foundation of the adaptive management approach. While targets and allocations are calculated using the best available data, the data are only an estimate of a complex ecological system. The MOS is put in place to reflect some of this uncertainty, but other issues only become apparent when restoration strategies are underway. Having a monitoring strategy in place allows for feedback on the effectiveness of restoration activities (whether TMDL targets are being met), if all significant sources have been identified, and whether attainment of TMDL targets is feasible. Data from long-term monitoring programs also provide technical justifications to modify restoration strategies, targets, or allocations where appropriate. Some field procedures have been revised since data collection for TMDL development, and all future monitoring should adhere to standard DEQ protocols. Where applicable, analytical detection limits must be below the numeric standard.

The monitoring strategy presented in this section provides a starting point for the development of more detailed and specific planning efforts regarding monitoring needs; it does not assign monitoring responsibility. Monitoring recommendations provided are intended to assist local land managers, stakeholder groups, and federal and state agencies in developing appropriate monitoring plans to meet aforementioned goals. Funding for future monitoring is uncertain and can vary with economic and political changes. Prioritizing monitoring activities depends on stakeholder priorities for restoration and funding opportunities.

7.2 Adaptive Management Approach

An adaptive management approach is recommended to control costs and meet the water quality standards to support all beneficial uses. This approach works in cooperation with the monitoring strategy, and as new information is collected, it allows for adjustments to restoration goals or pollutant targets, TMDLs, and/or allocations, as necessary.

7.3 Future Monitoring Guidance

The objectives for future monitoring in the Upper Jefferson watershed include: 1) strengthening the spatial understanding of sources for future restoration work, which will also strengthen source assessment analysis for future TMDL review, 2) investigating weak links in the existing conditions assessments if needed, 3) identifying streams that should be investigated further because of indications that sediment TMDLs may be needed, and 4) tracking restoration projects as they are implemented and assessing their effectiveness.

7.3.1 Strengthening Source Assessment Prior to Restoration Work

Sediment TMDLs have been developed for six water body segments in the Upper Jefferson TPA. Since data was collected for the sediment source assessment, DEQ has modified several aspects of the procedure, including standardizing procedures for selecting representative sediment/habitat sampling sites. These modifications, as well as others identified by DEQ, should be considered during follow-up monitoring. Strengthening source assessments should also include assessment of future sources as they arise. The extent of monitoring should be consistent with the extent of potential impacts. In addition, monitoring can vary from basic BMP compliance inspections to establishing baseline conditions and measuring target parameters below the project area both before and after project completion. Cumulative impacts from multiple projects must also be considered. This approach will help track the recovery of the system and the impacts, or lack of impacts, from ongoing management activities in the watershed. Therefore, additional targets and other water quality goals may need to be developed to address new stressors to the system. If new sources do occur, the new data should be used to update TMDL allocations.

Many parts of the watershed have naturally erosive geology. Although human-caused sources exacerbate erosion, additional monitoring is recommended to gain a better understanding of natural sediment loading from streambank retreat (erosion) rates. These watersheds include the Big Pipestone, Little Pipestone, Hells Canyon, Cherry, Fish, and Whitetail creeks. Streambank retreat rates are part of the equation for calculating sediment loading from near-stream sediment sources for sediment TMDLs and allocation. The current sediment TMDLs are calculated using literature values for streambank retreat rates. Measuring streambank retreat rates on water bodies within the Upper Jefferson TPA would be useful to verify or revise the current TMDLs and would also be useful for completing or revising sediment TMDLs in other watersheds throughout Montana in similar settings. Bank retreat rates can be determined by installing bank pins at different positions on the streambank at several transects across a range of landscapes and stability ratings. Bank erosion is documented after high flows and throughout the year for several years to capture retreat rates under a range of flow conditions.

Sediment from both paved and unpaved roads is significant throughout the tributary watersheds of the Upper Jefferson TPA. Though the paved road assessment focused solely on the influence of the I-90 corridor, future monitoring should expand to include source assessment monitoring along Little Pipestone Creek and MT State Highway 2.

7.3.2 Impairment Status Monitoring and Recommended Future Assessments

The Montana Department of Environmental Quality (DEQ) is the lead agency for developing and conducting impairment status monitoring. Other agencies or entities may work closely with DEQ to provide compatible data if interest arises. Impairment determinations are conducted by the state but can use data collected from other sources. The information in this section provides general guidance for future impairment status monitoring.

Sediment TMDLs were not completed in Fitz Creek and Halfway Creek even though controllable human-caused sources were present because sediment conditions in the stream could

not be clearly linked to aquatic life impacts. Further stream bottom content and pool measurements should occur to verify this. Monitoring should follow all DEQ recommended Standard Operating Procedures for sediment and habitat assessments.

DEQ is currently considering overall biological health and also sediment related metrics for periphyton assessments. The new metrics may provide additional relevant information relating to beneficial uses and should be considered during future TMDL reviews.

Currently, Homestake Creek, tributary to Big Pipestone Creek, is not listed as impaired by sediment. However, source assessment data suggests that significant human-caused sources are present. Though sediment TMDLs were developed for Big Pipestone Creek at the watershed scale, hence incorporating its tributaries into the TMDL and allocations, future impairment monitoring and evaluation is recommended specifically for Homestake Creek.

7.3.3 Effectiveness Monitoring for Restoration Activities

The following recommendations are categorized by the type of restoration practice to which they apply.

7.3.3.1 Road BMPs

Monitoring road sediment delivery is necessary to determine if BMPs are effective, to determine which are most effective, and to determine which practices or sites require modification to achieve water quality goals. Effectiveness monitoring should be initiated before implementing BMPs at treatment sites.

Monitoring actual sediment routing is difficult or prohibitively expensive. It is likely that budget constraints will influence the number of monitored sites. Once specific restoration projects are identified, a detailed monitoring study design should be developed. To overcome environmental variances, monitoring at specific locations should continue for a period of two to three years after BMPs are initiated.

Specific types of monitoring for separate issues and improvements are listed in **Tab**le 7-**1**.

Table 7-1. Monitoring Recommendations for Road BMPs

Road Issue from Section 10.0 (Restoration)	Restoration Recommendation	Monitoring Recommendation	Recommended Methodology
Ditch Relief Combined with Stream Crossings	• Re-engineer & rebuild roads to completely disconnect inboard ditches from stream crossings. Techniques may include: • Ditch relief culverts • Rolling dips • Water Bars • Outsloped roads • Catch basins • Raised road grade near stream crossing	• Place silt trap directly upslope of tributary crossing to determine mass of sediment routed to that point • Rapid inventory to document improvements and condition	• Sediment yield monitoring based on existing literature/USFS methods • Revised Washington Forest Practices Board methodology
Ditch Relief Culverts	• Consider eliminating the inboard ditch and outsloping the road or provide rolling dips • When maintaining/ cleaning ditch, do not disturb toe of cutslope • Install culverts with proper slope and angle following Montana road BMPs • Armor culvert outlets • Construct stable catch basins • Vegetate cutslopes above ditch • Increase vegetation or install slash filters, provide infiltration galleries where culvert outlets are near a stream	• Rapid inventory to document improvements and condition • Silt traps below any ditch relief culvert outlets close to stream	• Revised Washington Forest Practices Board methodology • Sediment yield monitoring based on existing literature/USFS methods
Stream Crossings	• Place culverts at streambed grade and at base of road fill • Armor and/or vegetate inlets and outlets • Use proper length and diameter of culvert to allow for flood flows and to extend beyond road fill	• Repeat road crossing inventory after implementation • Fish passage and culvert condition inventory	• Revised Washington Forest Practices Board methodology • Montana State (DNRC) culvert inventory methods

Table 7-1. Monitoring Recommendations for Road BMPs

Road Issue from Section 10.0 (Restoration)	Restoration Recommendation	Monitoring Recommendation	Recommended Methodology
Road Maintenance	• Avoid casting graded materials down the fill slope & grade soil to center of road, compact to re-crown • Avoid removing toe of cut slope • In some cases graded soil may have to be removed or road may have to be moved	• Repeat road inventory after implementation • Monitor streambed fine sediment (grid or McNeil core) and sediment routing to stream (silt traps) below specific problem areas	• Revised Washington Forest Practices Board methodology • Standard sediment monitoring methods in literature
Oversteepened Slopes/General Water Management	• Where possible outslope road and eliminate inboard ditch • Place rolling dips and other water diverting techniques to improve drainage following Montana road BMPs • Avoid other disturbance to road, such as poor maintenance practices and grazing	• Rapid inventory to document improvements and condition	• Revised Washington Forest Practices Board methodology

7.3.3.2 Agricultural BMPs

Grazing BMPs reduce grazing pressure along streambanks and riparian areas. Implementing BMPs may improve water quality, create narrower channels and cleaner substrates, and result in recovery of streambank and riparian vegetation. Effectiveness monitoring for grazing BMPs should be conducted over several years, making sure to start monitoring before BMPs are implemented. If possible, monitoring reaches should be established in pastures keeping the same management as well as in those that have changed. Where grazing management includes moving livestock according to riparian use level guidelines, it is important to monitor changes within the growing season as well as over several years. Monitoring recommendations to determine seasonal and long-term changes resulting from implementing grazing BMPs are outlined below in **Table 7-2**.

Table 7-2. Effectiveness Monitoring Recommendations for Grazing BMPs by Restoration Concern

Recovery Concern	Monitoring Recommendations	Methodology or Source
Seasonal impacts on riparian area and streambanks	Seasonal monitoring during grazing season using riparian grazing use indicators • Streambank alteration • Riparian browse • Riparian stubble height at bank and "key area"	BDNF/BLM riparian standards (Bengeyfield and Svoboda, 1998)
Long-term riparian area recovery	• Photo points • PFC/NRCS Riparian Assessment (every 5-10 yrs) • Vegetation Survey (transects perpendicular to stream and spanning immediate floodplain) every 5-10 years • Strip transects- Daubenmire 20cm x 50cm grid or point line transects	Harrelson et al., 1994; Bauer and Burton, 1993; NRCS, 2001 Stream Assessment Protocols
Streambank stability	Greenline including bare ground, bank stability, woody species regeneration (every 3-5 years)	Modified from Winward, 2000
Channel stability	Cross-sectional area, with % fines/ embeddedness • Channel cross-section survey • Wolman pebble count • Grid or McNeil core sample	Rosgen, 1996; Harrelson et al., 1994
Aquatic habitat condition	• Aquatic macroinvertebrate sampling • Pool quality • R1/R4 aquatic habitat survey	DEQ biomonitoring protocols; Hankin and Reeves, 1988; USFS 1997 R1R4 protocols
General stream corridor condition	EMAP/Riparian Assessment (every 5-10 yrs)	NRCS 2001 Stream Assessment Protocols; U.S. EPA 2003.

7.2.3.4 Other Restoration Activities

This TMDL assessment has revealed the importance of beavers to stream systems within the Upper Jefferson TPA. Beavers are important for managing water and sediment runoff and allowing recovery of riparian zones. Re-establishing populations in some areas may be an important tool for restoring natural channel dynamics and healthy riparian zones. Alternatively, beavers may cause problems by moving into irrigation networks and may need to be managed closely. Monitoring is needed to identify areas that can support beaver populations, define habitat requirements to determine potential reintroduction success, and determine positive and negative influences of beaver reintroduction on channel stability, fish habitat, water quality and quantity, riparian habitat, and aquatic and terrestrial wildlife. Specific monitoring needs will depend on the nature of reintroduction efforts and site-specific requirements.

7.2.3.5 Watershed-Scale Monitoring

As restoration activities are implemented, watershed-scale monitoring may be valuable in determining if restoration activities are improving water quality, instream flow, and aquatic habitat and communities. It is important to remember that degradation of aquatic resources happens over many decades and that restoration is also a long-term process. An efficiently executed long-term monitoring effort is an essential component to any restoration effort.

Due to the natural high variability in water quality conditions, trends in water quality are difficult to define and even more difficult to relate directly to restoration or other changes in management. Improvements in water quality or aquatic habitat from restoration activities will most likely be evident in fine sediment deposition and channel substrate embeddedness, changes in channel cumulative width/depths, improvements in bank stability and riparian habitat, increases in instream flow, and changes in communities and distribution of fish and other bio-indicators. Specific monitoring methods, priorities, and locations will depend heavily on the type of restoration projects implemented, landscape or other natural setting, the land use influences specific to potential monitoring sites, and budget and time constraints.

SECTION 8.0
PUBLIC INVOLVEMENT

This section will be completed after the Public Comment period and will be included in the final version of the document.

SECTION 9.0
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APPENDIX A

WATERSHED CHARACTERIZATION REPORT
JEFFERSON RIVER WATER QUALITY RESTORATION PLANNING AREAS

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1.0 WATERSHED CHARACTERIZATION

This document has been prepared to provide an overview of watershed characteristics in the Jefferson River drainage of southwestern Montana. It is intended to provide a general understanding of physical, climatic, hydrologic, and other ecological features within the Jefferson watershed. This watershed characterization report is a companion to a second document, the *Jefferson Watershed Water Quality Status Report*, which reviews and describes water quality conditions of streams within the Jefferson drainage basin and provides monitoring recommendations. Together, the reports are intended to provide a foundation for water quality restoration planning and implementation activities by the Jefferson River Watershed Council, the Jefferson Valley Conservation District, and cooperating landowners and agencies.

1.1 Physical Characteristics

1.1.1 Location

The Montana Department of Environmental Quality (DEQ) has divided the Jefferson River watershed into two regions (Upper and Lower. See map **Figure 1**) for purposes of developing water quality restoration plans. These planning area designations have been used in this report for purposes of organizing the watershed characterization information. The terms “watershed” and “planning area” are used interchangeably throughout the report.

The Upper Jefferson River Planning Area encompasses a geographic area of approximately 469,994 acres, and the Lower Jefferson River Planning Area encompasses approximately 385,649 acres, for a combined total area of 855,643 acres (NRIS 2002). The boundary of the combined planning areas extends from Three Forks, MT at the watershed’s eastern extreme, south along the Madison/Jefferson hydrologic divide, turning east near the Willow Creek Reservoir and following the ridges of the Tobacco Root Mountains to the vicinity of Twin Bridges, MT. From this point, the boundary turns north, following the Big Hole/Jefferson divide through the Highland Mountains, eventually passing just east of Butte, and then north of Whitetail Reservoir. The watershed boundary then roughly follows the Boulder River divide south and east back to Three Forks. The combined planning area includes portions of Jefferson, Madison, Broadwater, Gallatin, and Silver Bow counties**,** and has diverse federal, state, and private ownership (**Figure 1**).

Major rivers and streams within the planning area include the Jefferson River, which is approximately 83.5 miles in length, flowing north from Twin Bridges to Whitehall, then east to Cardwell and eventually to the Missouri River at Three Forks, as well as its larger tributaries including Pipestone Creek, Whitetail Creek, the South Boulder River, and Willow Creek. The tributary watersheds originate high in the Tobacco Root and Highland Mountains in the Beaverhead and Deerlodge National Forests and traverse a relatively wide, flat expanse of agricultural and range land before terminating at their confluence with the Jefferson River.

Seventeen streams or stream segments within the Jefferson watershed planning area have appeared on DEQ's *Montana 303(d) List: A Compilation of Impaired and Threatened Waterbodies in Need of Water Quality Restoration*. Waters placed on this list are suspected of failing to meet state-designated water quality standards, and restoration plans are required to be developed. Ten of these streams are located in the Upper Jefferson River Planning Area, including Big Pipestone Creek, Cherry Creek, Dry Boulder Creek, Fish Creek, Fitz Creek, Halfway Creek, Hells Canyon Creek, Little Pipestone Creek, Whitetail Creek, and the Jefferson River from its headwaters to its confluence with Big Pipestone Creek. The remaining seven streams are in the Lower Jefferson River Planning Area and include Charcoal Creek, North Willow Creek, Norwegian Creek, the South Boulder River, South Willow Creek, Willow Creek, and the Jefferson River from Big Pipestone Creek to the Missouri River (MDEQ 2002a, MDEQ 2002b) (**Figure 2**).

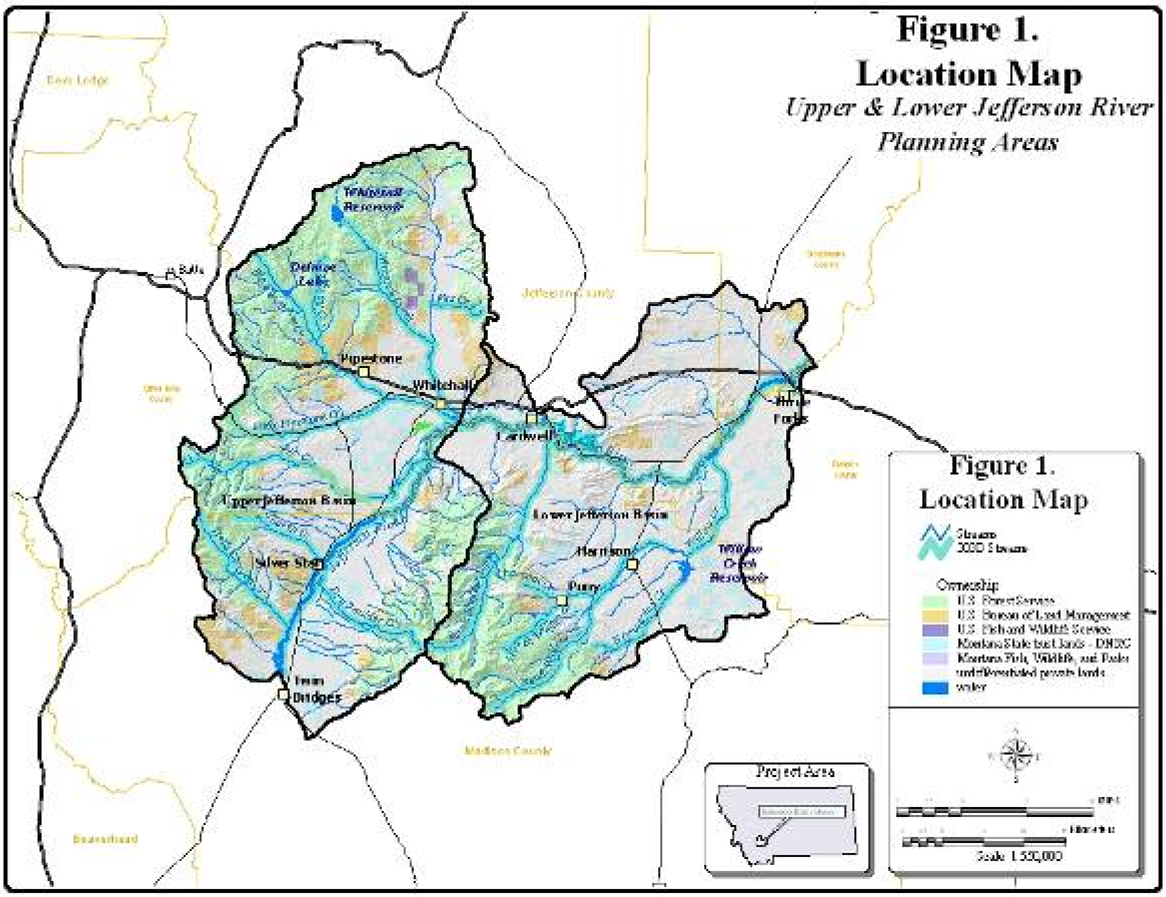


Figure 1. Location Map Upper and Lower Jefferson River Planning Areas.

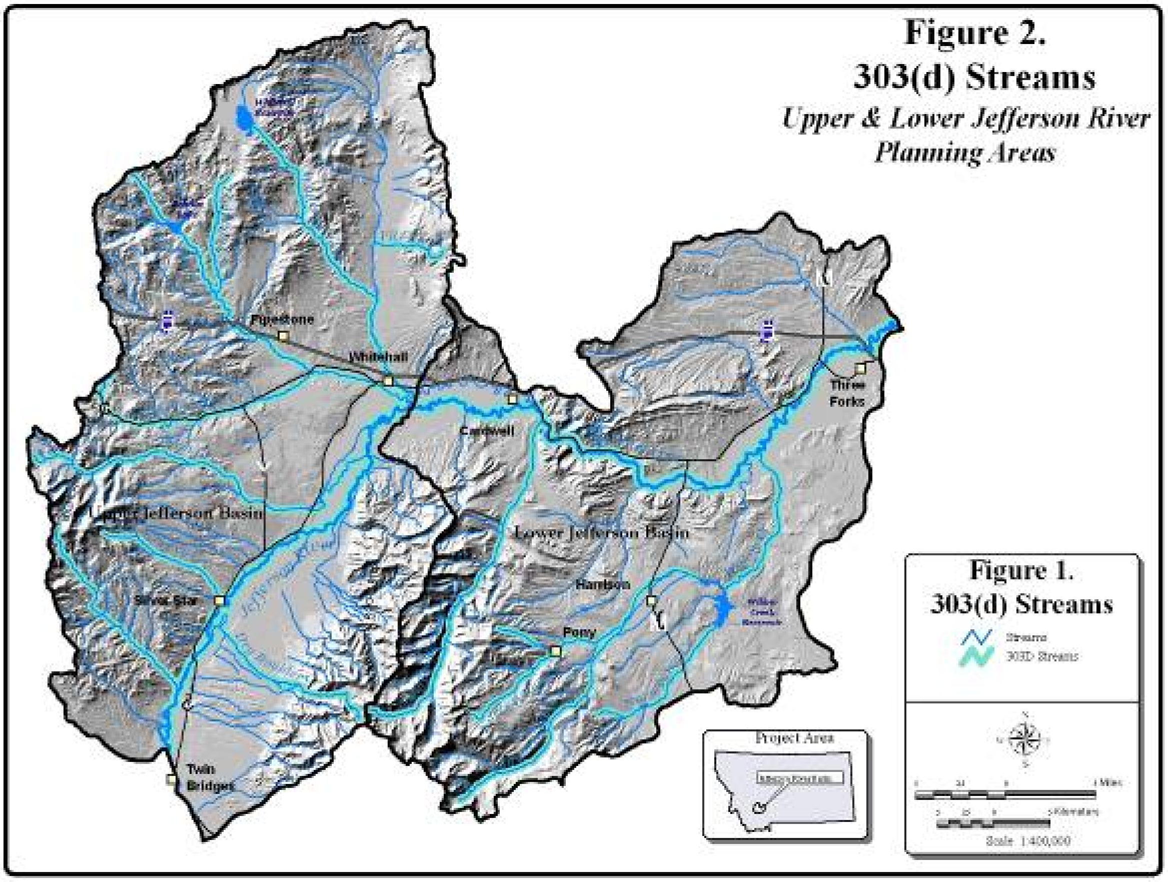


Figure 2. 303(d) Streams

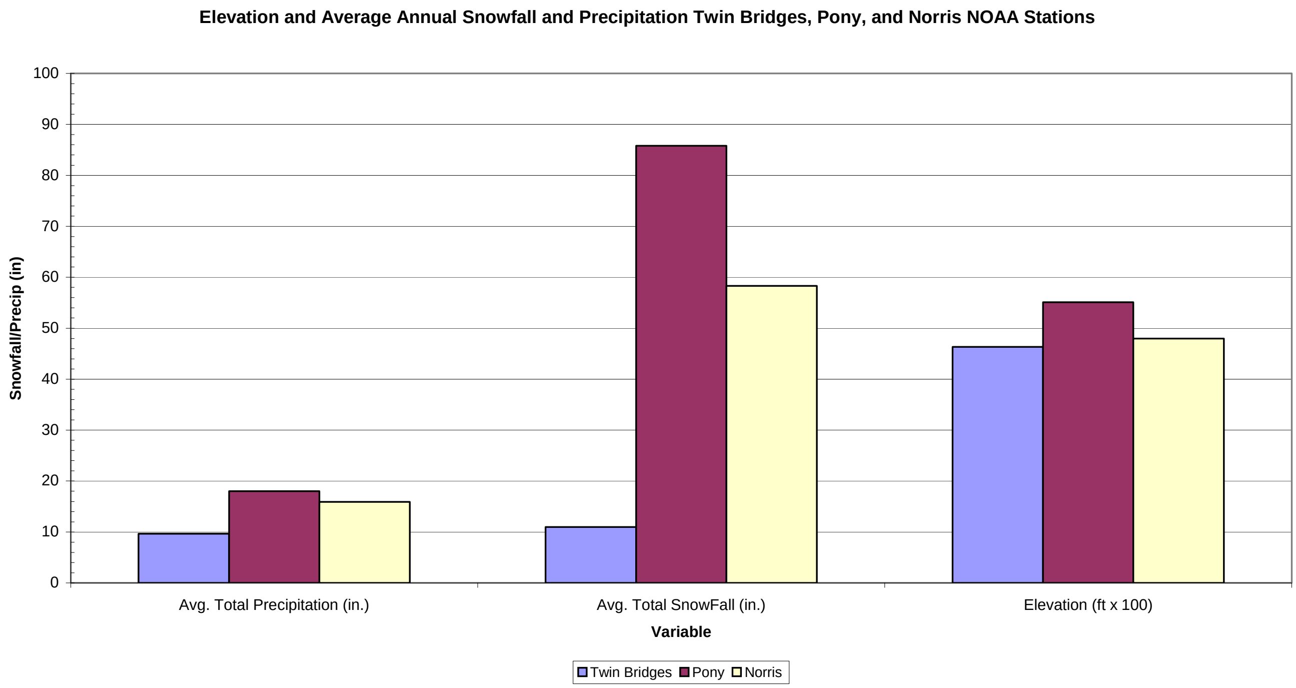
1.1.2 Climate

Three National Oceanic and Atmospheric Administration (NOAA) stations were selected to represent climatic conditions in the Jefferson watershed (Twin Bridges #248430, Pony #246655, and Norris #246153). The Norris station is located just outside of the southeastern boundary of the watershed; the stations at Twin Bridges and Pony are within the watershed. The period of record differs at the three stations: Norris (1957 to 1982), Pony (1959 to 1998), Twin Bridges (1950 to 2002).

Unfortunately, the elevation range covered by the NOAA stations extends only from 4,630 feet at Twin Bridges to 5,510 feet at Pony. It should be noted that elevations in the Jefferson River Planning Area extend beyond 10,000 feet, and that the selected stations do not fully represent meteorological conditions in higher elevation portions of the mountainous region. However, precipitation shows strong orographic effects even across this relatively small elevation change. Annual precipitation at 4,630 feet in Twin Bridges averages 9.65 inches/year with 11 inches of annual snowfall. Average annual precipitation at the mid-elevation station in Norris (4,800 ft) increases to 15.91 inches/year with 58.3 inches of annual snowfall; and average annual

precipitation increases further at the Pony site (5,510 feet), where average annual precipitation is 18.02 inches/year with 85.8 inches of snowfall (**Figure 3**). While elevation differences undoubtedly account for some of the variability in precipitation between these sites, weather patterns are also strongly influenced by surrounding mountain peaks, which exceed 10,000 feet in the Tobacco Roots. NOAA climate data were obtained from the Western Regional Climate Center at http://www.wrcc.dri.edu/summary/climsmmt.html.

Figure 3. Average Annual Precipitation



Average annual precipitation and temperature patterns for the three selected stations are presented in **Figures 4, 5,** and **6**. Temperature patterns are similar for all three stations, with July the warmest month and January the coldest at all stations. Summertime highs are typically in the high seventies to low eighties F, and winter lows fall to approximately 11 degrees F (**Table 1**). Precipitation patterns also reveal a high degree of consistency between the three NOAA stations, with May and June being the wettest months at all sites and winter precipitation dominated by snowfall. A complete summary of NOAA climatic data for the selected stations is presented in **Appendix A**.

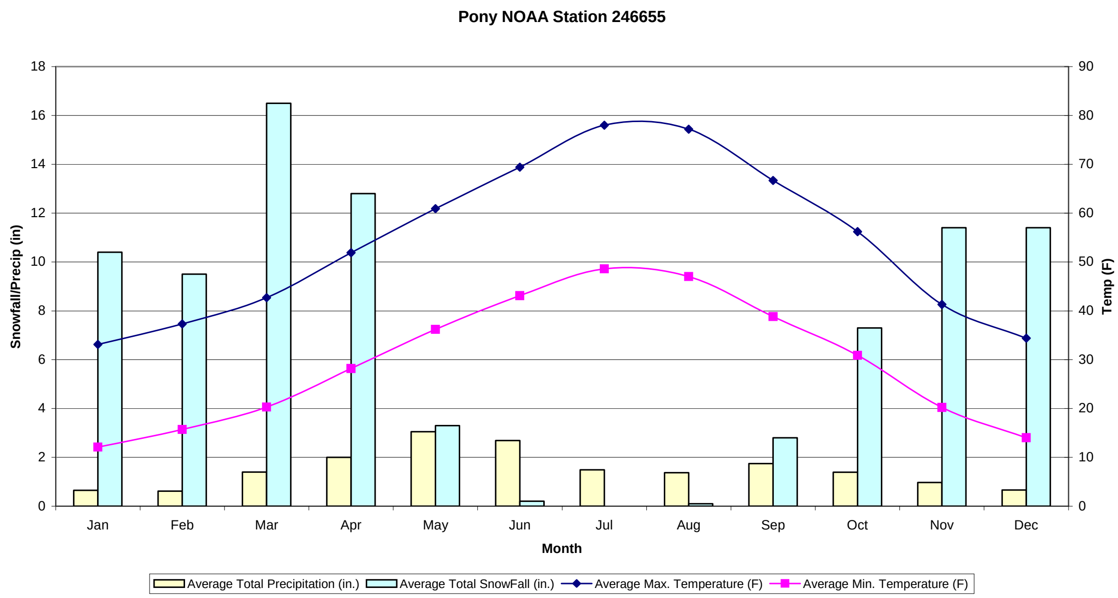


Figure 4. Average Annual Precipitation and Temperature Patterns for Pony

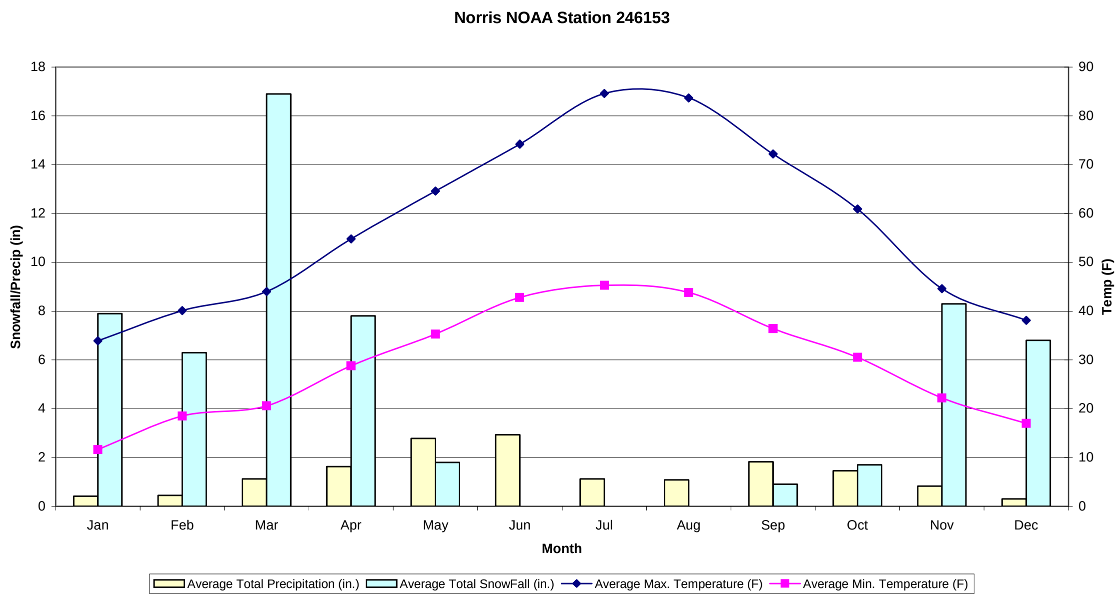


Figure 5. Average Annual Precipitation and Temperature Patterns for Norris

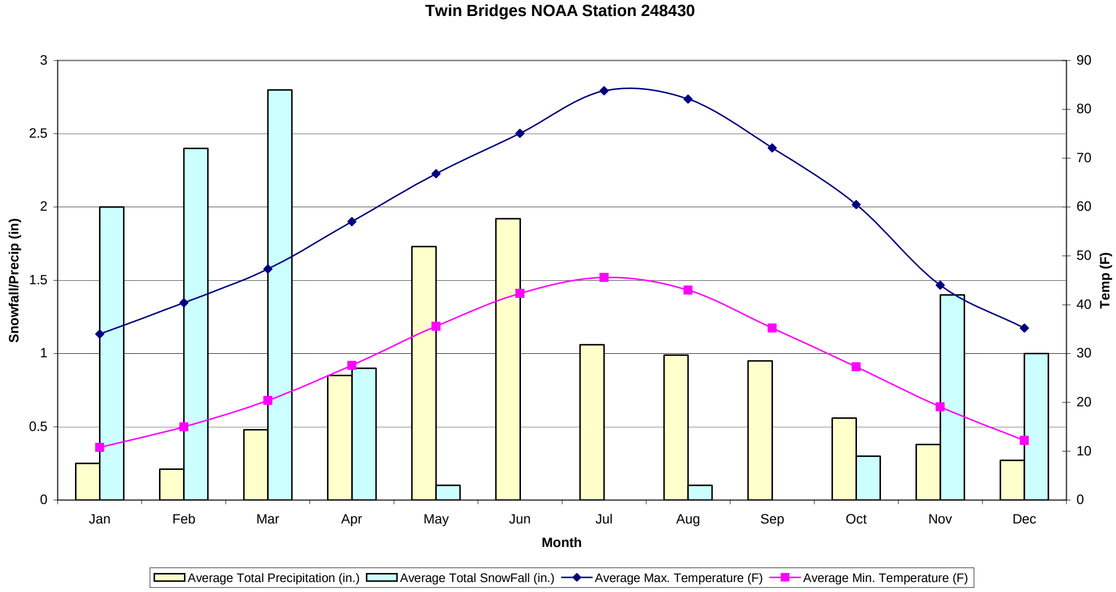


Figure 6. Average Annual Precipitation and Temperature Patterns for Twin Bridges

Table 1. Average January, July, and Annual Minimum and Maximum Temperatures at the Twin Bridges, Pony, and Norris NOAA Climate Stations (degrees F)

Station	Average January Min/Max Temperatures	Average July Min/ Max Temperatures	Av Annual Min/Max Temperatures
Twin Bridges	10.8/34.0	45.6/83.8	27.8/58.2
Pony	12.1/33.1	47.0/77.2	29.6/54.1
Norris	11.6/33.9	45.3/84.6	29.4/58.0

1.1.3 Hydrology

The U.S. Geological Survey (USGS) Montana water resources information database (http://montana.usgs.gov/) lists 24 stream flow gauging stations with current and historical flow data in the Jefferson River Planning Areas (**Appendix B**). Long-term flow data were selected for six stations on 303(d)-listed streams to obtain a general understanding of seasonal stream flow characteristics in the Jefferson watershed. These stations included the Jefferson River near Twin Bridges, Jefferson River near Three Forks, Whitetail Creek near Whitehall, Willow Creek near Harrison, Willow Creek near Willow Creek, and Norwegian Creek near Harrison (**Table 2** and **Figure 7**).

Table 2. Selected USGS Stream Gauges in the Jefferson River Planning Areas

USGS #	Station ID	Period of Record	Drainage Area (mi^2)
06026500	Jefferson River near Twin Bridges	1940-1943, 1958-1972, 1994-present	7,632
06036650	Jefferson River near Three Forks	1978-present	9,532
06029000	Whitetail Creek near Whitehall	1949-1968	30.8
06035000	Willow Creek near Harrison	1938-present	83.8
06036500	Willow Creek near Willow Creek	1919-1933, 1946-1953, 1955-1957	165
06035500	Norwegian Creek near Harrison	1938-1943, 1946-1951	22.4

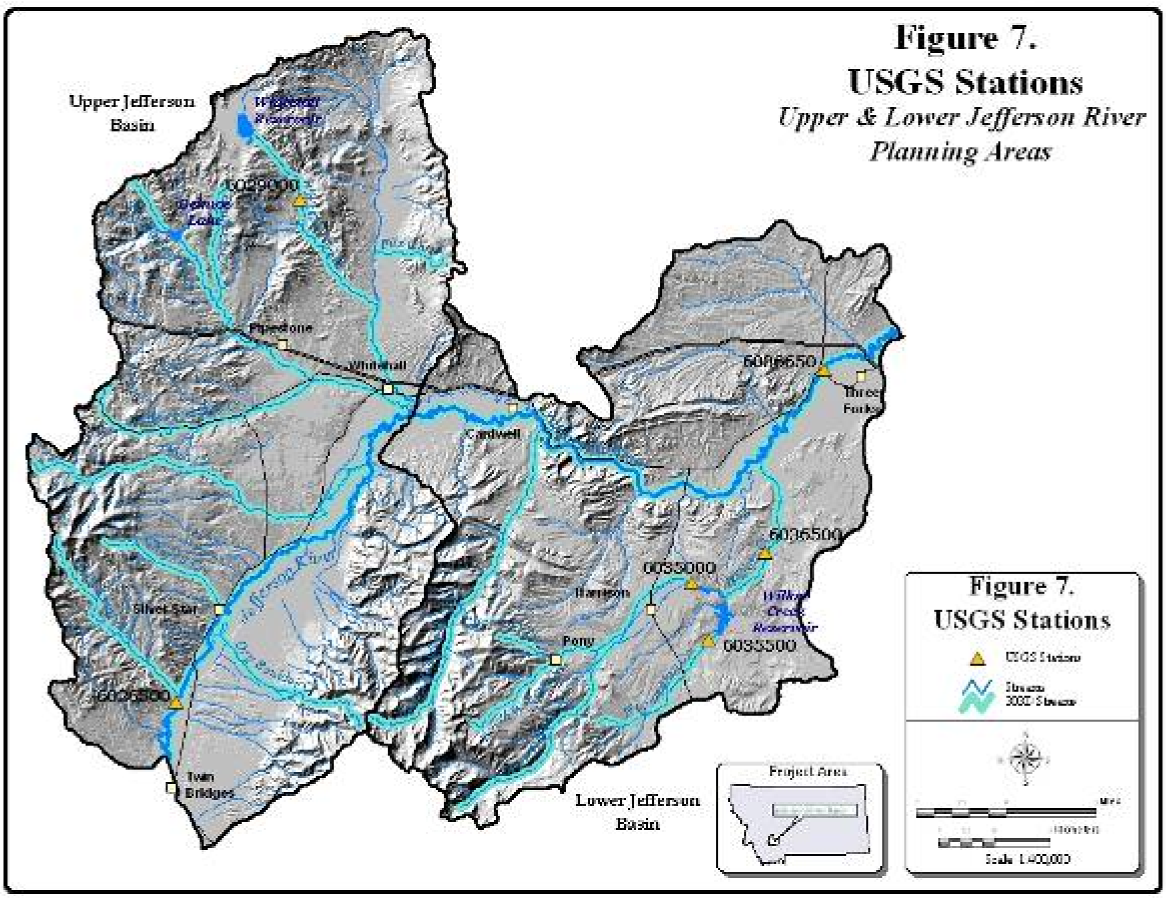


Figure 7. USGS Stations

Average discharge patterns for the two Jefferson River gaging sites are presented in **Figure 8**. The period of record for the two stations differs as described in **Table 2**. Average monthly flows for the two stations show similar seasonal patterns, with relatively constant flows of between 1,000 and 1,700 cubic feet per second (cfs) during the fall and winter months. Observed

increases in stream flows in September and October probably reflect decreasing irrigation water withdrawals or possibly irrigation return flows in these months. Spring high flows begin in March, the hydrographs peak in June, and the recessional limbs begin in late June/early July. Since about 1980, recurring drought has resulted in summer stream flows that are considerably lower than those represented by the long-term average, with flows as low as 59 cfs recorded at Three Forks in August of 1988.

Average monthly stream flows for the four tributary stations are presented in **Figure 9**. Base flows in Whitetail Creek during the fall and winter average between 1.5 and 2.5 cfs. In April, flows begin to increase, peaking in June at 41.9 cfs and then declining through the summer and early fall, with a small increase in flow in August. The Whitetail Creek hydrograph is influenced to some degree by flows released from Whitetail Reservoir, which is located in the headwaters.

Norwegian Creek is one of the primary sources of water for the Willow Creek Reservoir. The Norwegian Creek hydrograph reveals relatively little variation in flow, with baseflows of approximately 4 cfs and peak flows of about 10 cfs, reflecting a small drainage area and, perhaps, the influence of springs. However, the Norwegian Creek data is at least 50 years old, and may not accurately represent current conditions. The two Willow Creek sites show similar seasonal patterns with flows increasing in the spring in conjunction with melting snows and increasing precipitation, peaking in June at both sites and receding through July and August. Baseflows are higher at the downstream site near Willow Creek, MT, reflecting the contribution of water from Willow Creek's tributaries and a larger drainage area at this site. However, the data from this site is at least 50 years old and may not accurately reflect current water supply and stream flow conditions (**Figure 9**).

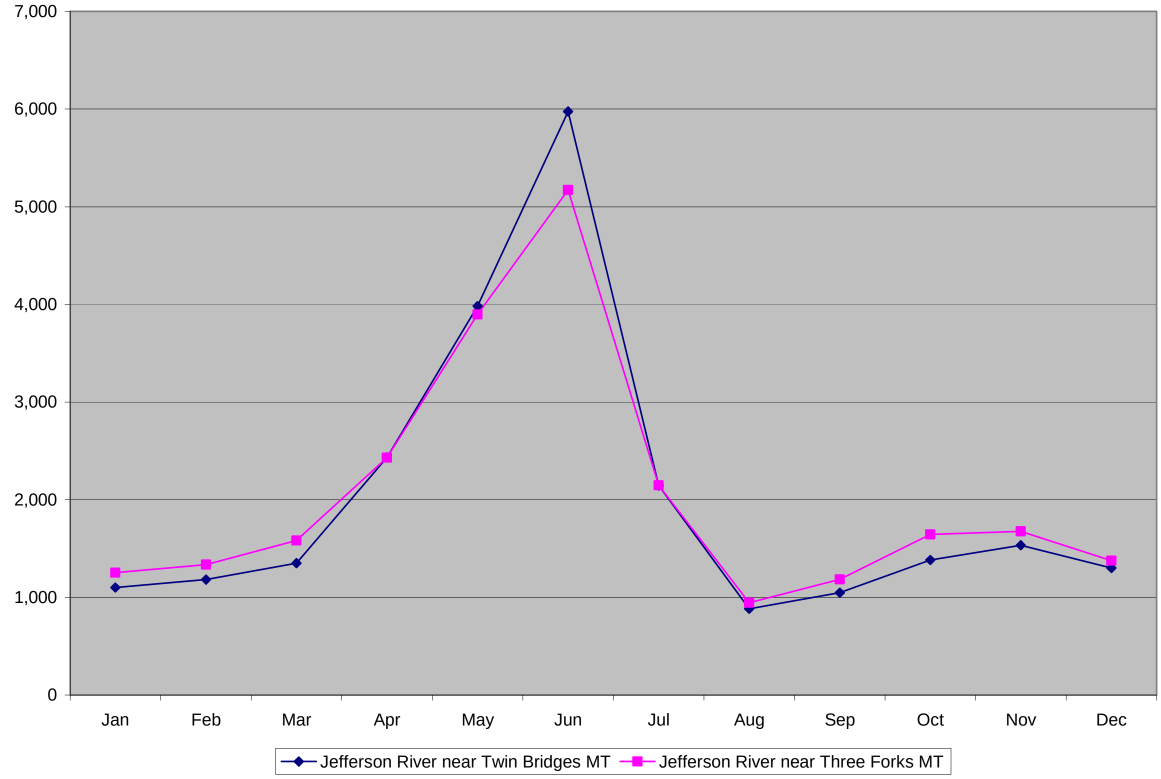


Figure 8. Average Monthly Flows at 2 USGS Jefferson River Gauging Stations

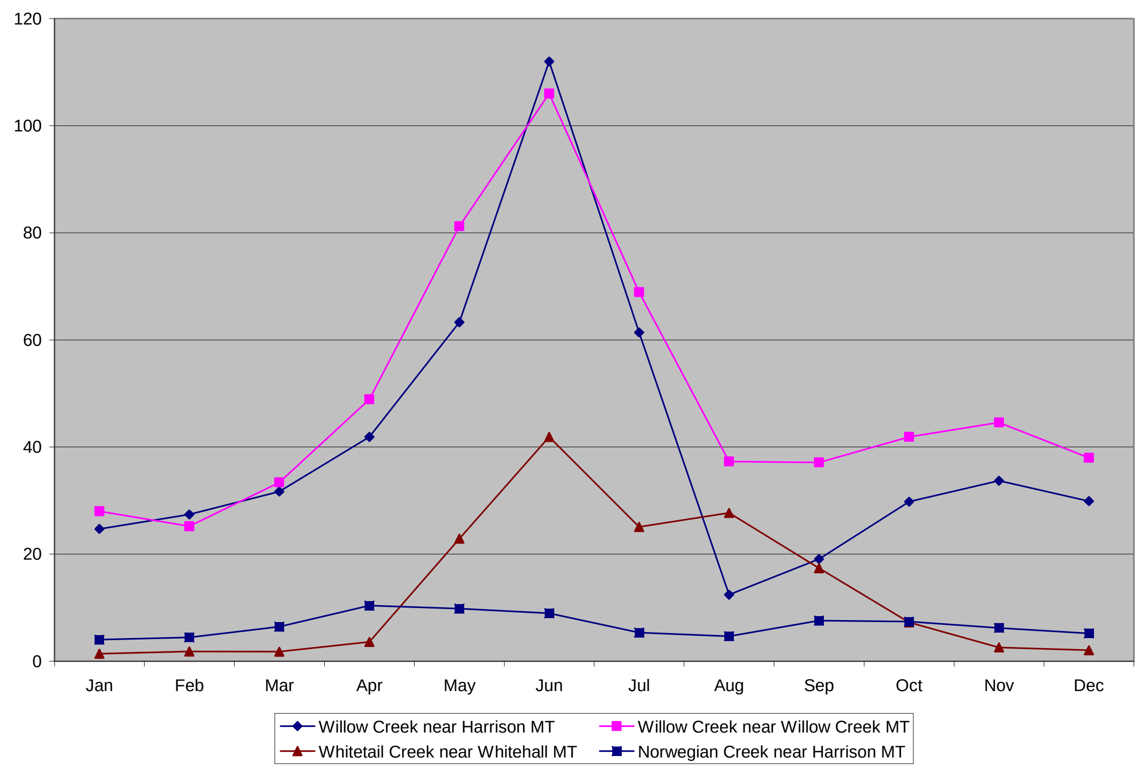


Figure 9. Average Monthly Flows at 4 USGS Gauging Stations on 303(d)-listed Streams

1.1.4 Irrigation Practices

The locations of irrigated lands within the Jefferson River watershed were recently compiled by the Montana Department of Natural Resources and Conservation (DNRC). These data are presented in **Figure 10**. The data consist of the estimated locations of recorded points of diversion and points of use for all active water rights within the DNRC water rights database. The shaded polygons were generated from legal land descriptions associated with water rights in the database and do not represent actual field boundaries (Horton 2003). Also presented are irrigation reservoirs and the major ditches for which mapping data are currently available from the DNRC. Within the Upper Jefferson Planning Area, 42,384 acres, or 9 percent of the total land area, is irrigated. In the Lower Jefferson Planning Area, 58,544 acres, or 15 percent of the total land area, is irrigated. In the two planning areas combined, 100,928 acres, or 12 percent of the total land area, is irrigated.

Nearly 85 percent of all irrigation in the Jefferson River Planning Areas occurs in Madison and Jefferson counties, which account for 86 percent of the total land area (**Table 3**). Madison County represents 46 percent of the Jefferson watershed land area and 56 percent of the basin's irrigated lands. Jefferson County represents 40 percent of the watershed land area, and 28 percent of the irrigated lands.

Table 3. Irrigation by County in the Jefferson River Planning Areas

County	Irrigated Acres	% of Irrigated Lands	Total Acres in Planning Area	% of County Irrigated	% of Land in Planning Area
Madison	56,795	56%	393,484	14%	46%
Jefferson	28,510	28%	340,834	8%	40%
Gallatin	12,400	12%	4,9295	25%	6%
Broadwater	2,639	3%	32,282	8%	4%
Silver Bow	585	1%	39,730	1%	5%
Total in Planning Area	**100,929**	**100%**	**855,625**	**12%**	**100%**

The Montana Water Resources Surveys for Silver Bow (1955), Madison (1965), Broadwater (1956), Gallatin (1961), and Jefferson (1956) counties were reviewed to provide a summary of major irrigation projects in the Jefferson River Planning Area (**Table 4**). While some of the data may be outdated, the table provides a useful comparison of some of the more important components of the irrigation water distribution systems.

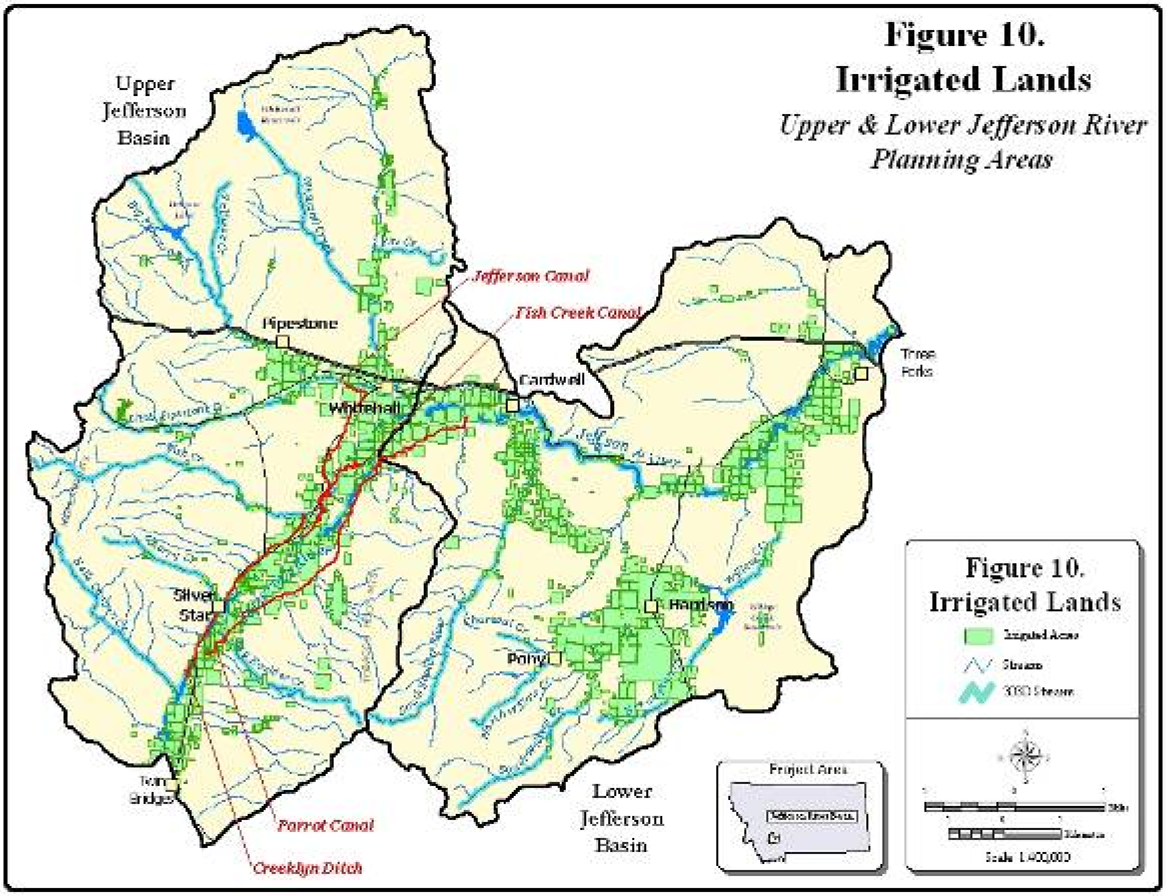


Figure 10. Irrigated Lands

Table 4. Major Irrigation Projects in the Jefferson River Planning Areas

Project Name	Counties	Source	Date Complete	Capacity (CFS)	Length (mi)	Irrigated Acres
Willow Creek Storage Project	Madison, Gallatin	Willow Cr. Res	1938	Not avail.	Not avail.	12000
Parrot Ditch Co.	Madison	Jefferson River nr Silver Star	1888	Not avail.	26	4000
Pipestone Ditch Co. and Pipestone Water Users Assn.	Jefferson	Delmoe Lake, Big Pipestone Cr.	1908	200	9	3500
Fish Creek Ditch Co. and Pleasant Valley Ditch	Jefferson, Silver Bow	Jefferson River nr Waterloo	1885	200	12	3000
Old Hale Ditch Co.	Jefferson, Broadwater	Jefferson River nr Sappington	1898	50	7.5	1500
Jefferson Canal Co.	Jefferson	Jefferson River nr Waterloo	1906	50	8	1200

Six major irrigation projects account for about 25 percent (approximately 25,000 acres) of the total irrigated acreage in the Jefferson Watershed Planning Area. The remaining 75 percent of

irrigated lands in the planning area are served by numerous smaller irrigation projects (<1000 acres) and private ditches. The largest irrigation project in the planning area, the Willow Creek Storage Project, has one main storage reservoir: Willow Creek Reservoir; known locally as Harrison Lake. The reservoir has a capacity of 17,000 acre-feet of water with the potential to irrigate 12,000 acres in the Willow Creek Valley near Harrison and Willow Creek.

Another significant irrigation project is the Parrot Ditch Co., which has the potential to irrigate approximately 4000 acres in the planning area. This 26-mile long ditch parallels the Jefferson River from Silver Star to Cardwell, and intercepts a large portion of flow from the west and north slopes of the Tobacco Root Mountains. This project provides irrigation water to the bench areas south of Whitehall from Waterloo to Cardwell.

1.1.5 Channel Morphology

Channel morphology data for streams in the Jefferson River watershed are limited. The primary source of data on channel morphology located for this report was the U.S. Forest Service's draft of the Jefferson River Water Quality Restoration Plan (Salo 2002), which summarized channel morphology conditions based primarily on Rosgen Level II stream assessments. Because the primary focus of the USFS report was to address water quality impacts on federal lands, channel morphology on private lands may differ from what is described here. For the purposes of their assessment, the USFS divided the Jefferson Watershed into five hydrologic units (5th code HUCs): Big Pipestone, Hells Canyon, South Boulder River, and South and North Willow Creeks. Information contained in the USFS report and other available references are summarized in the following paragraphs:

Big Pipestone 5th code HUC (1002000502)
Most streams within this HUC (hydrologic unit code) lie within the granitic Boulder Batholith and are therefore nutrient poor, coarse-grained, and highly susceptible to erosion. Management activities within the watershed include roads and trails, timber harvest, mining, and grazing. Reservoir management affects the timing and magnitude of streamflow and sediment routing on Big Pipestone and Whitetail Creeks (Salo 2002). Streams within this HUC that appear on the 303(d) list include Big Pipestone Creek, Little Pipestone Creek, Halfway Creek, Whitetail Creek, and Fitz Creek, which appear in bold in **Table 5**. The USFS provided no data on Fitz Creek, so information was obtained from a 1994 riparian inventory conducted by the University of Montana's Riparian and Wetland Research Program (available at www.nris.state.mt.us).

Table 5. Stream Morphology and Functional Status Summary for Selected Streams in the Big Pipestone 5th Code HUC
(303(d)-listed streams appear in bold type)

Stream	Existing Stream Type	Potential Stream Type	Function Status	Support for Function Status (listed in order of importance)
Beaver	B5	E5	NF	Grazing, roads, timber harvest
Beefstraight	F5, E5	E5	NF, F@R	Grazing, roads, placer mining
Bigfoot	B4, G4	B4	F@R	Roads, timber harvest, grazing
Big Pipestone (BLM)	**B5c**	**B5c, C5**	**F@R**	**Roads and Trails, Reservoir management**
Big Pipestone (below Res.)	**F4**	**B4**	**NF**	**Reservoir management**
Dearborn	C4	E4a	NF	Grazing, timber harvest
Fitz[1]	**C4, B4**	**?**	**NF**	**Grazing**
Grouse	E5	E5	F	Presently functioning, but vulnerable
Halfway (down)	B5	E5	NF	Grazing, roads, placer mining
Halfway (up)	E6	E5	F@R	Grazing
Haney	B4c	B4c	F	Within Roadless
International	B4	E4	NF	Placer mining
Little Pipestone	**G4c**	**E4**	**NF**	**Highway, Railroad, placer mining**
Moose	E6	E6	F	None Provided
NF Little Pipestone	B4c	E4	NF	Grazing, Roads
O’Neil	G5c	E5	NF	Bank instability, entrenchment – causes not known
Pappas (down)	F4/G4	E4	NF	Roads, timber harvest, grazing
Pappas (up)	G4	E4	NF	Channel entrenchment causes not known
State (BLM)	G5	E5	NF	Grazing, roads, timber harvest
Toll Canyon	G4	E4	NF	Grazing, roads/trails
Whitetail	**B5c**	**E5**	**F@R**	**Grazing, reservoir management**
Whitetail	**B4c**	**C4**	**NF**	**Grazing, reservoir management, roads**

1. Data for Fitz Creek were obtained from a 1994 RWRP inventory, not from the USFS.
NF = not functioning; F@R = functioning at risk; F = functioning

Hells Canyon 5th code HUC (1002000501)
The Hells Canyon/Fish Creek area includes glaciated belt rock and stream dissected granitics, while glaciated and stream dissected schists, gneiss and associated metamorphics dominate watersheds in the Tobacco Roots and slopes are steep in many areas. Many of the streams flowing from the Tobacco Roots go subsurface as they leave the confinement of the mountains, which may result in part from the existence of coarse grained alluvial fans in this area. Many streams in this HUC experience little management activity on federal lands due to steep, rugged landscapes with little access, particularly in the upper reaches of Cherry, and Hells Canyon Creeks, as well as portions of Fish Creek. Grazing and roads have contributed to sediment

loading and channel morphology degradation on portions of Hells Canyon and Fish Creeks, and portions of Fish Creek have been heavily altered by placer mining (Salo 2002). Four streams in the Hells Canyon 5th code HUC appear on the 303(d) list, including Cherry Creek, Dry Boulder Creek, Fish Creek, and Hells Canyon Creek (**Table 6**). A summary of stream types is presented in **Appendix G.**

Table 6. Stream Morphology and Functional Status Summary for Selected Streams in the Hells Canyon 5th Code HUC
(303(d)-listed streams appear in bold type)

Stream	Existing Stream Type	Potential Stream Type	Function Status	Support for Function Status (listed in order of importance)
Bear Gulch	E4b	E4b	F@R	Placer mining, grazing, roads
Cherry Creek	**?**	**?**	**?**	**?**
Dry Boulder	**A3**	**A3**	**F**	**None provided**
EF Hells Canyon	E4b, B4	E4b	F@R	Grazing
Fish	**B4**	**E4**	**NF**	**Grazing, roads, placer mining**
Hells Canyon	**C4b, B4**	**C4**	**F@R**	**Grazing**
Hells Canyon (lower)	**C4b**	**C4**	**F@R**	**Roads, grazing**
Horse	A4	B4	NF	Placer mining
Mill	B4a	B4	F@R	Roads, grazing, timber harvest

NF = not functioning; F@R = functioning at risk; F = functioning

South Boulder River 5th code HUC (1002000505)

The lower South Boulder watershed consists mainly of stream dissected schists and gneiss, while the upper portion is valley glaciated schists and gneiss dominated by steep slopes. Land use activities in the area are dominated by grazing and mining, with some road building and housing development in the valley bottom (Salo 2002). Morphology and functional status of select streams in this HUC are summarized in **Table 7**. The South Boulder River is the only stream in the HUC that appears on the 303(d) list, but it was not surveyed by the USFS. A summary of stream types is presented in **Attachment G.**

Table 7. Stream Morphology and Functional Status Summary for Selected Streams in the South Boulder River 5th Code HUC

Stream Reach	Existing Stream Type	Potential Stream Type	Function Status	Support for Function Status (listed in order of importance)
Carmichael	B5a	A4	NF	Grazing
EF South Boulder	E4	E4	F	Roadless
NF McGovern	E4	E4	F@R	Grazing
Park	B4c, E4	E4	NF	Grazing, mining
Pole Canyon	B4	E4b	NF	Grazing

NF = not functioning; F@R = functioning at risk; F = functioning

South and North Willow Creeks 5th code HUC (1002000506)
Landforms and geology in this area include glaciated granitics on both South and North Willow Creeks, with valley glaciated schists/gneiss in the lower basins. Although mining impacts exist, and roads, trails, and livestock grazing affect water quality on a localized basis, most of the upper basin is within inventoried roadless areas (Salo 2002). In the lower basin, however, streams are more heavily impacted. 303(d) listed streams within this HUC include Charcoal Creek, North Willow Creek, South Willow Creek, Willow Creek, and Norwegian Creek. The USFS has not yet conducted stream morphology surveys in the Willow Creek hydrologic units, but it is their judgment that streams located on federal lands in this area can be classified as functioning (Salo 2000).

1.1.6 Topography, Slope, and Relief

Figure 11 displays the topography of the Jefferson River Planning Areas, **Figure 12** displays the distribution of slope, and a shaded relief map is presented in **Figure 13**. Relief in the Jefferson River Planning Areas ranges from about 4000 feet in the Jefferson River Valley to over 10,000 feet in the Tobacco Root Mountains (**Table 8**).

Slightly less than half of the combined planning area (40.91%) is between 4,000 and 5,000 feet in elevation, with this lowest of the elevation categories comprising a slightly larger fraction of the Lower Jefferson River Planning Area (53.94%) than of the Upper Jefferson River Planning Area (30.22%). Approximately 94 percent of the combined planning area is below 8,000 feet in elevation.

The slope in the Jefferson River Planning Areas ranges from less than 1 percent to over 100 percent, with the largest fraction of both planning areas in the 10 to <25 percent slope category (**Table 9, Figure 12**). Approximately 90 percent of the combined planning area has a slope of <45 percent.

Topography and relief data were obtained from the United States Geological Survey's National Elevation Dataset for Montana, available at: http://nris.state.mt.us/nsdi/nris/ned.html.

Table 8. Elevation in the Jefferson River Planning Areas

Category (ft)	Upper Jefferson		Lower Jefferson		Combined Total		
	Acres	% of area	Acres	% of area	Acres	% of area	Cum %
4,000-5,000	142,086	30.22	207,929	53.94	350,015	40.91	40.91
5,000-6,000	129,971	27.65	98,995	25.68	228,966	26.76	67.67
6,000-7,000	103,443	22.00	26,036	6.75	129,480	15.13	82.80
7,000-8,000	71,560	15.22	23,796	6.17	95,356	11.14	93.94
8,000-9,000	17,775	3.78	18,202	4.72	35,977	4.20	98.14
9,000-10,000	5,031	1.07	9,488	2.46	14,519	1.70	99.84
10,000-11,000	249	0.05	1062	0.28	1,310	0.15	100.00
Totals	470,115	100.00	385,508	100.00	855,622	100.00	

Table 9. Slope in the Jefferson River Planning Areas

Category (ft)	Upper Jefferson		Lower Jefferson		Combined Total		
	Acres	%	Acres	%	Acres	%	Cum %
<1%	24,272	5.16	25,228	6.54	49,500	5.79	5.79
1 to <5%	86,175	18.33	78,295	20.31	164,470	19.22	25.01
5 to <10%	69,574	14.80	75,900	19.69	145,474	17.00	42.01
10 to <25%	133,413	28.38	103,998	26.98	237,411	27.75	69.76
25 to <45%	104,679	22.27	63,020	16.35	167,699	19.60	89.36
45 to <100%	51,827	11.02	38,603	10.01	90,430	10.57	99.93
>100%	176	0.04	463	0.12	638	0.07	100.00
Totals	470,115	100.00	385,507	100.00	855,622	100.00	

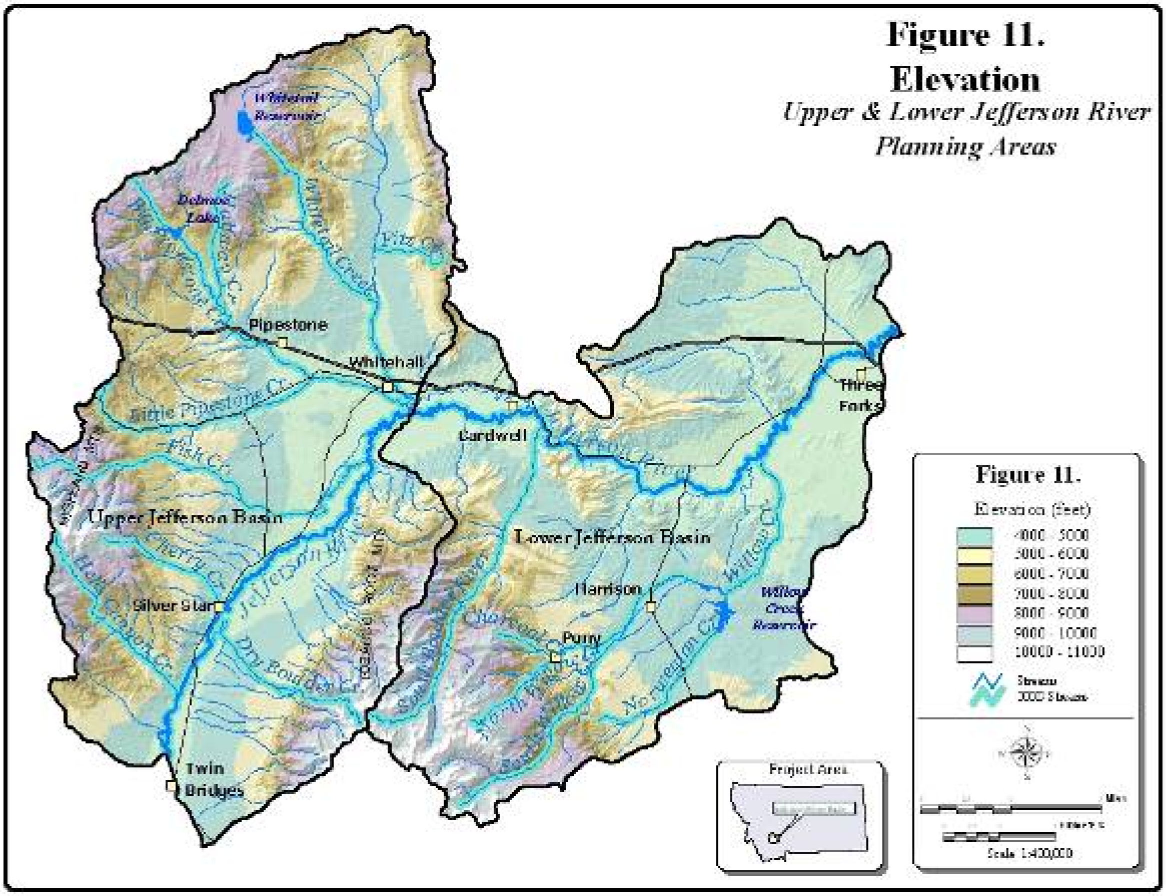


Figure 11. Elevation

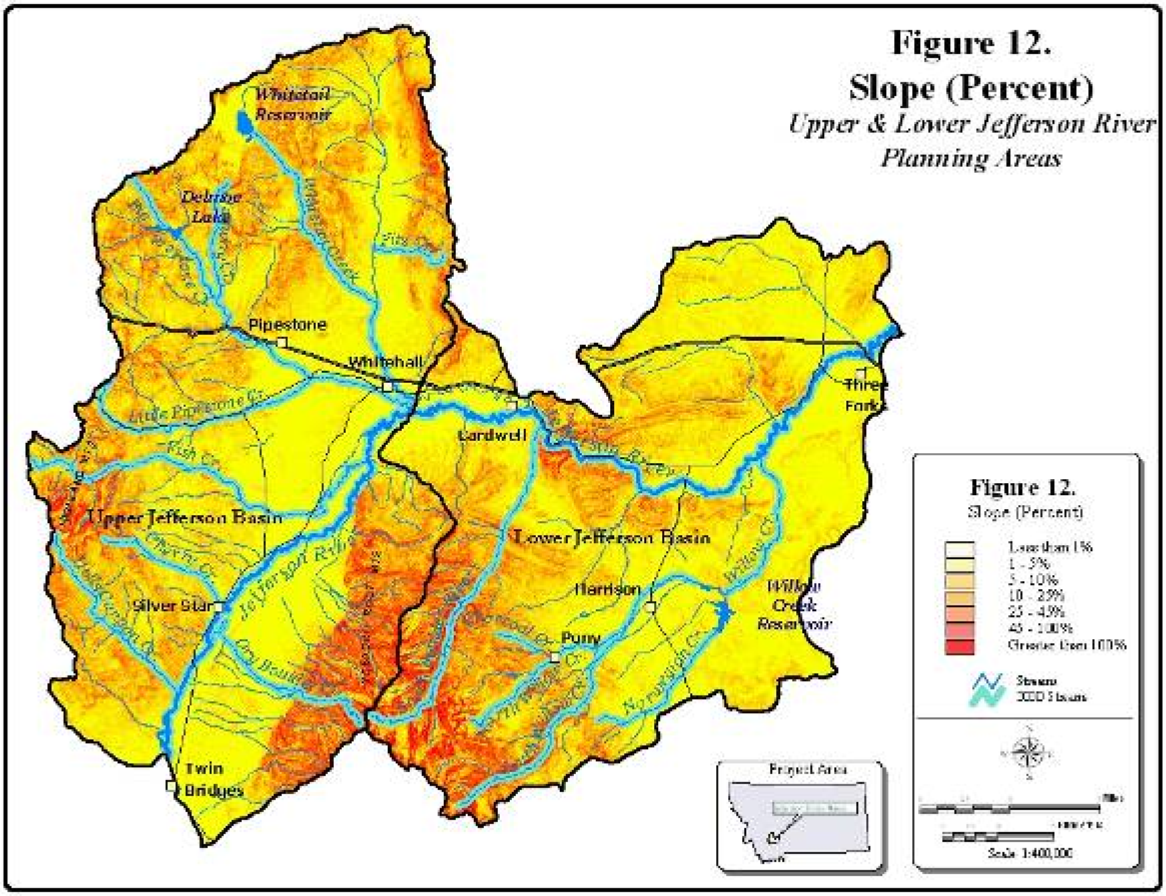


Figure 12. Slope (percent)

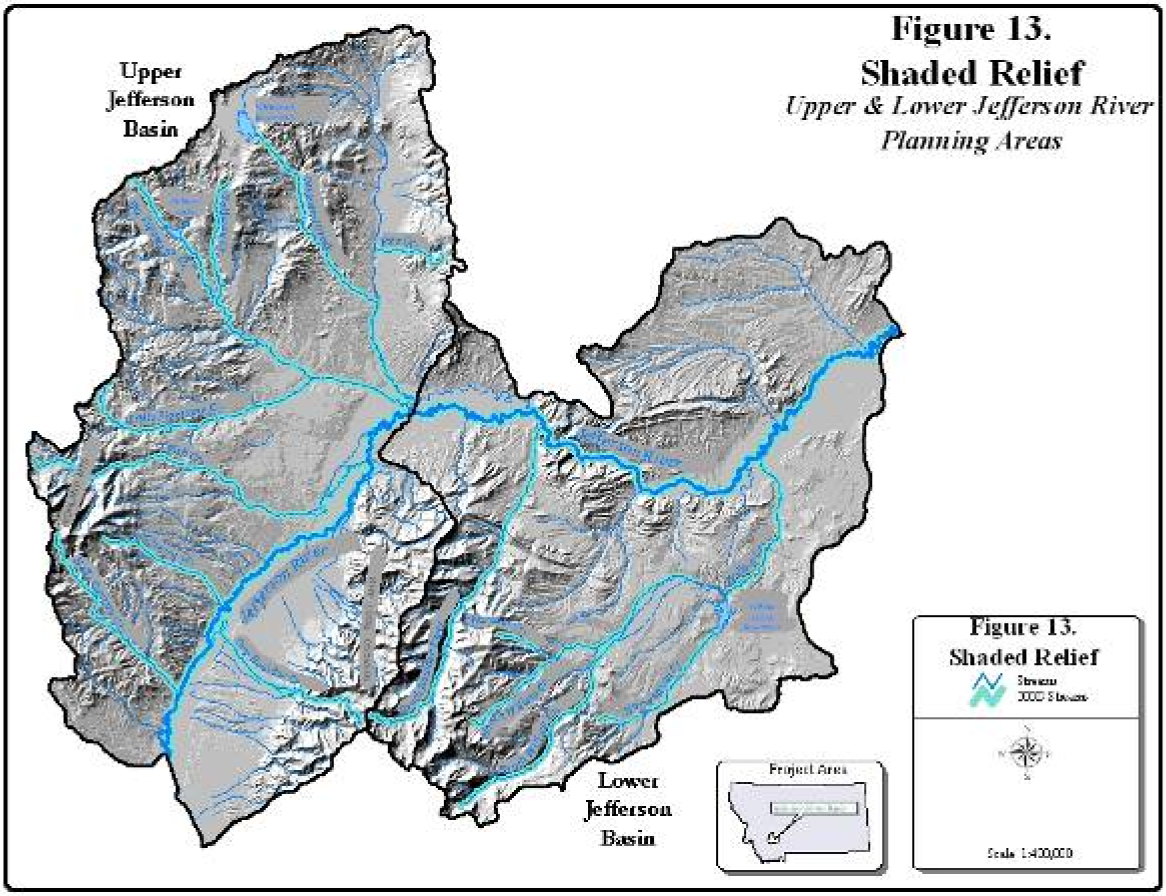


Figure 13. Shaded Relief

1.1.7 Major Land Resource Areas

The U.S. Department of Agriculture (USDA) has established Major Land Resource Areas (MLRAs) for the United States. The MLRAs are large area land resource units geographically associated according to the dominant physical characteristics of topography, climate, hydrology, soils, land use, and potential natural vegetation. Two MLRAs are found in the Jefferson watershed area and each is characterized by unique physiography, geology/soil types, climate, potential natural vegetation, and land use (**Table 10** and **Figure 14**). The majority of the Jefferson River Planning Area is classified as Northern Rocky Mountain Valleys (78% of the Upper Jefferson, 81% of the Lower Jefferson, 80% of the combined area). The Northern Rocky Mountains unit comprises the remainder of the planning areas. Complete descriptions of the MLRAs are found in **Attachment C**.

MLRA data was obtained from the USDA's State Soil Geographic Database, available at: http://water.usgs.gov/GIS/metadata/usgswrd/ussoils.html.

Table 10. Major Land Resource Areas of the Jefferson River Planning Areas

Classification		Acres	Square Miles	% of Planning Area
Upper Jefferson	Northern Rocky Mt. Valleys	366,917	573	78
	Northern Rocky Mts.	103,194	161	22
Lower Jefferson	Northern Rocky Mt. Valleys	313,514	490	81
	Northern Rocky Mts.	71,999	112	19
Combined Jefferson	Northern Rocky Mt. Valleys	175,193	274	20
	Northern Rocky Mts.	680,431	1063	80

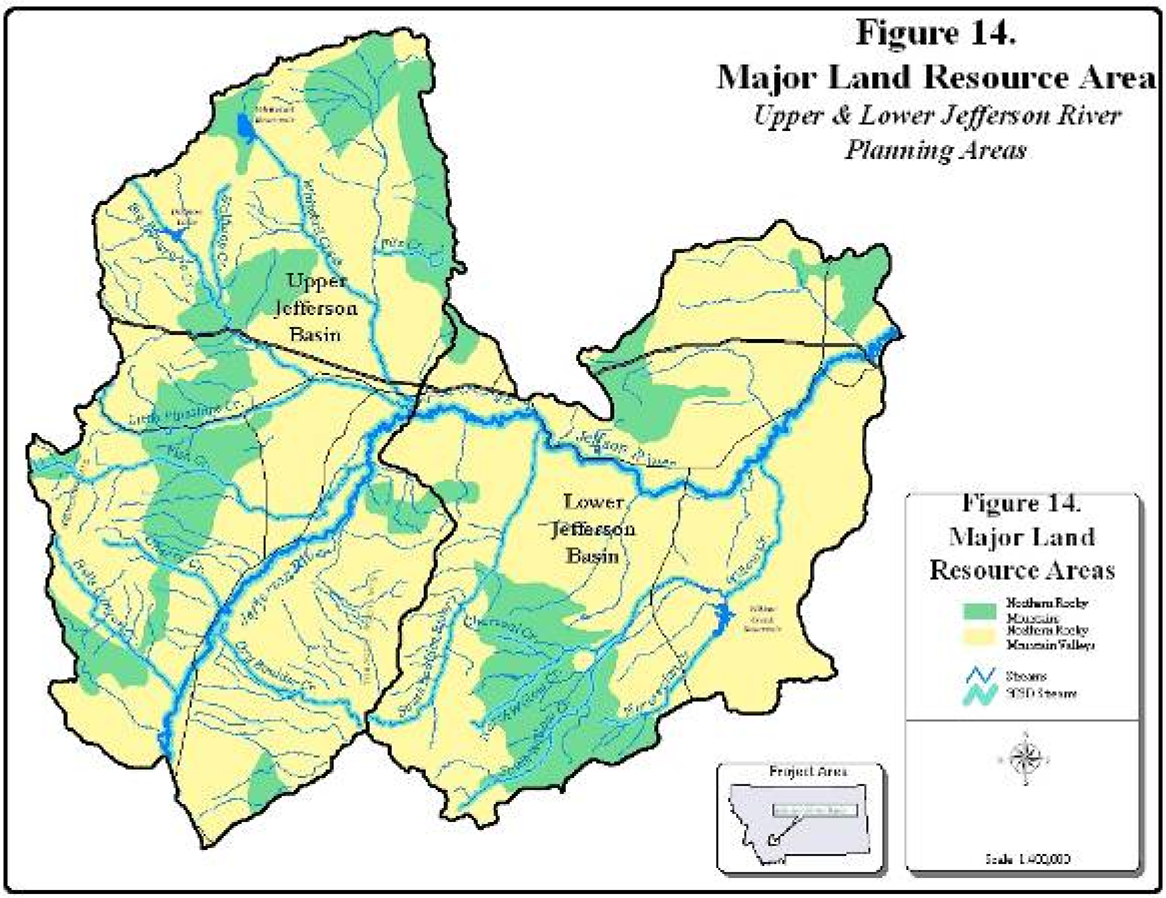


Figure 14. Major Land Resource Area

1.1.8 Land Ownership

The Jefferson River Planning Areas comprise approximately 855,618 acres, including 470,110 acres in the Upper Jefferson and 385,508 acres in the Lower Jefferson. Private lands dominate the ownership pattern in both planning areas, with 49.9 percent of the Upper Jefferson and 72.6 percent of the Lower Jefferson in private ownership, for a total of 57.2 percent of private

ownership across the combined planning areas. The U.S. Forest Service (USFS) controls 28.2 percent of the combined Jefferson River Planning Areas, and owns a larger portion of the upper planning area (38.6%) than the lower (15.6%). Eight percent of the combined planning areas is controlled by the U.S. Bureau of Land Management, and another 5.5 percent (including water) is controlled by the State of Montana. The remaining 0.7 percent of the combined planning areas is a mix of Montana Fish, Wildlife and Parks and U.S. Fish and Wildlife Service ownership (**Figure 15** and **Table 11).** Land ownership information was obtained from the Land Ownership and Managed Areas of Montana Database, available at: http://nris.state.mt.us/nsdi/nris/ms4.html.

Table 11. Land Ownership within the Jefferson River Planning Areas

Category (ft)	Upper Jefferson		Lower Jefferson		Combined Total		
	Acres	%	Acres	%	Acres	%	Cum %
Private Lands	209,911	44.7	279,792	72.6	489,703	57.2	57.2
U.S. Forest Service	181,325	38.6	60,229	15.6	241,554	28.2	85.4
U.S. Bureau of Land Management	54,101	11.5	17,157	4.5	71,258	8.3	93.7
Montana State Trust Lands - DNRC	21,585	4.6	23,136	6.0	44,721	5.2	98.9
Water	1,522	0.3	1,931	0.5	1,715	0.3	99.2
Montana Fish, Wildlife, & Parks	63	0.01	3,263	0.8	3,326	0.4	99.6
U.S. Fish and Wildlife Service	1,603	0.3	0	0	1,603	0.3	100.00
Totals	470,110	100.00	385,508	100.00	855,618	100.00	

1.1.9 Vegetative Cover

Vegetative data was summarized from Gap Analysis Program (GAP) information for the Jefferson River Planning Areas. GAP vegetation classifications were developed by the U.S. Geological Survey from satellite imagery collected in the 1990s (**Table 12** and **Figure 16**). This vegetation classification is highly detailed and attempts to differentiate individual species within general community types (i.e. Ponderosa Pine vs. Coniferous Forest). Ground truthing indicates that GAP data have limitations and the classification of individual species of polygons may be of variable quality. Nevertheless, GAP data represent the best available vegetation classification on a landscape scale. GAP data were obtained from the Montana 90-Meter Land Cover Database, available from the Montana State Library Natural Resource Information System at: http://nris.state.mt.us/nsdi/nris/gap90/gap90.html.

Eleven GAP vegetation classifications account for approximately 90 percent of the combined planning areas: grasslands are the primary vegetation type (44.7% including both low/moderate and very low cover grasslands), with grassland slightly more prevalent in the Lower Jefferson Planning Area than in the Upper. A mix of several forest types, including Douglas-fir, mixed

xeric forest, lodgepole pine, and mixed subalpine and whitebark pine accounts for 26.8 percent of the combined planning area, with forests slightly more common in the higher elevations of the upper planning area than in the lower; 7.52 percent of the combined planning area is sagebrush; irrigated and dry agricultural land combined account for 7.27 percent of the area; and 3.17 percent is comprised of montane parklands and subalpine meadows. The remaining 10 percent of the planning area is comprised of minor amounts of 21 additional GAP vegetation types.

Table 12. ***Vegetation Classification (GAP) within the Jefferson River Planning Areas***

Gap Vegetation Type	**Upper** (% of Planning Area)	**Lower** (% of Planning Area)	**Combined** (% of Planning Area)	**Combined Cum %**
Low/Moderate Cover Grasslands	28.46	42.09	34.60	34.60
Very Low Cover Grasslands	11.57	10.52	11.10	45.70
Douglas-fir	12.75	7.32	10.30	56.00
Sagebrush	6.60	8.64	7.52	63.52
Mixed Xeric Forest	9.50	3.66	6.87	70.39
Lodgepole Pine	7.80	0.86	4.67	75.06
Agricultural Lands – Irrigated	2.71	4.86	3.68	78.73
Agricultural Lands – Dry	1.90	5.66	3.59	82.32
Montane Parklands and Subalpine Meadows	3.22	3.10	3.17	85.49
Mixed Subalpine Forest	3.11	2.28	2.74	88.23
Mixed Whitebark Pine Forest	2.31	2.20	2.26	90.48
Douglas-fir/Lodgepole Pine	3.13	0.16	1.79	92.28
Rock	0.92	1.75	1.29	93.57
Shrub Riparian	0.93	1.04	0.98	94.55
Limber Pine	0.82	1.04	0.92	95.47
Mixed Riparian	0.91	0.85	0.88	96.35
Mixed Mesic Shrubs	0.39	0.61	0.49	96.84
Conifer Riparian	0.47	0.33	0.41	97.25
Mixed Broadleaf Forest	0.37	0.45	0.41	97.66
Water	0.35	0.43	0.39	98.05
Moderate/High Cover Grasslands	0.25	0.49	0.35	98.40
Mines, Quarries, Gravel Pits	0.13	0.45	0.28	98.68
Broadleaf Riparian	0.21	0.34	0.27	98.94
Mixed Xeric Shrubs	0.38	0.08	0.25	99.19
Alpine Meadows	0.09	0.43	0.25	99.44
Mixed Barren Sites	0.35	0.06	0.22	99.66
Mixed Broadleaf and Conifer Riparian	0.22	0.14	0.19	99.84
Urban or Developed Lands	0.06	0.14	0.10	99.94
Standing Burnt Forest	0.04	0.00	0.02	99.96
Ponderosa Pine	0.03	0.00	0.02	99.98
Rocky Mountain Juniper	0.02	0.00	0.01	99.99
Snowfields or Ice	0.00	0.02	0.01	100.00
Totals	100.00	100.00	100.03	

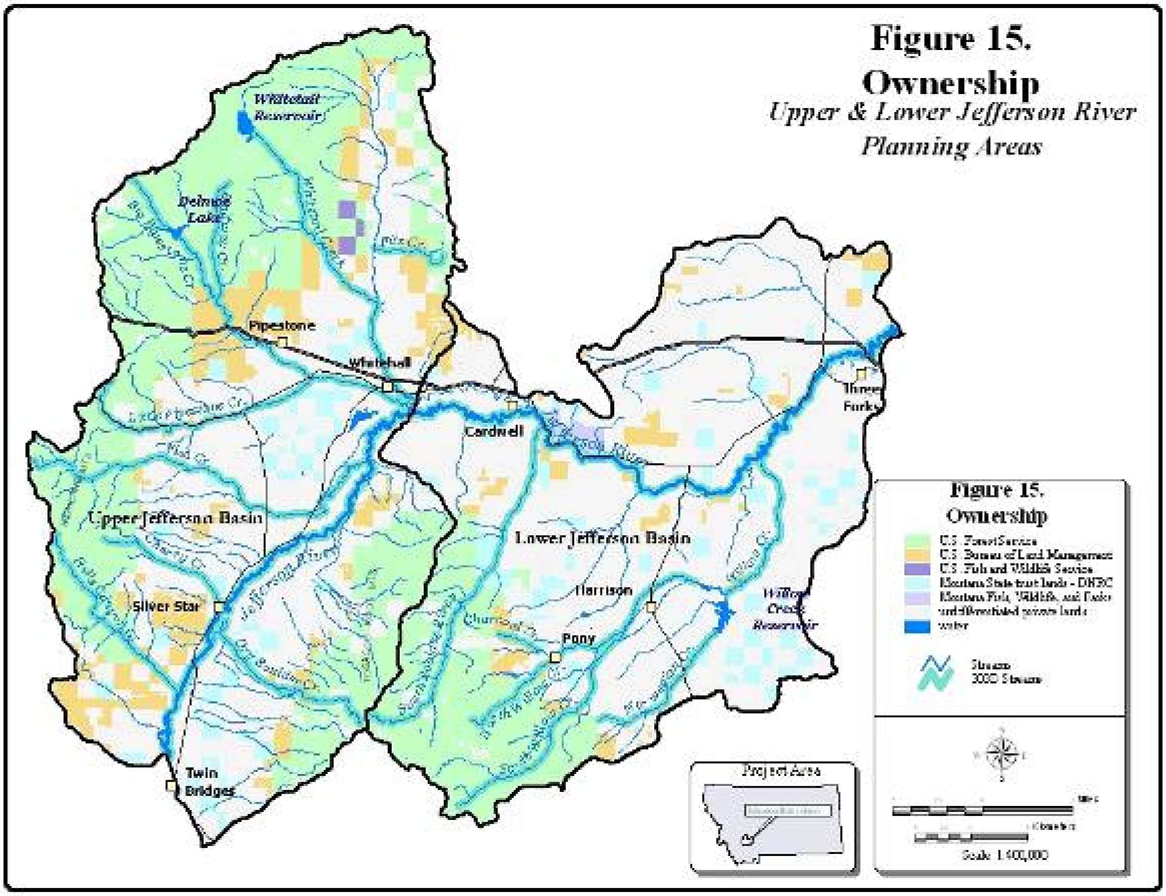


Figure 15. Ownership

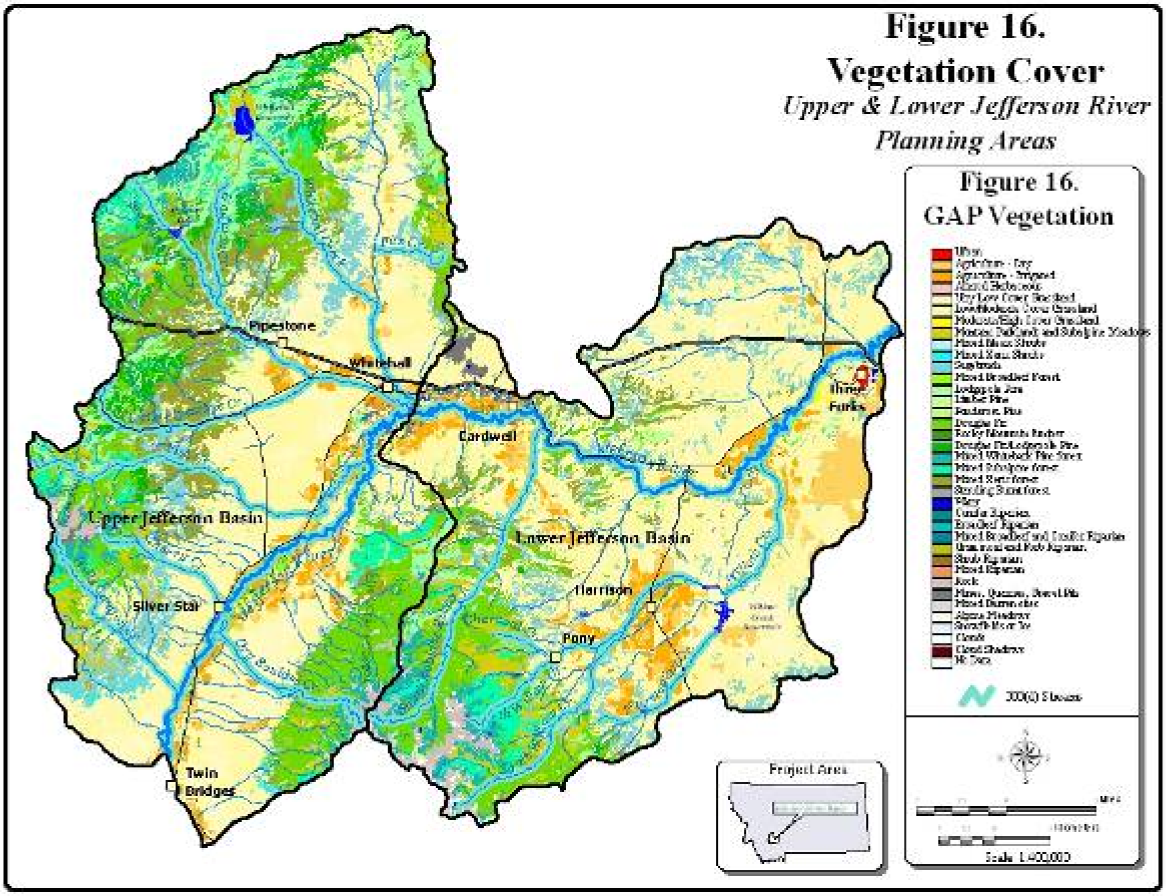


Figure 16. Vegetation Cover

1.1.10 Land Use and Land Cover

General land use and land cover data for the Jefferson River Planning Areas were derived from the Montana 90-Meter Land Cover Database, available at http://nris.state.mt.us/nsdi/nris/gap90/gap90.html, (**Table 13** and **Figure 17**). The Land Use and Land Cover (LULC) data files describe the vegetation, water, natural surface, and cultural features on the land surface.

The combined Jefferson River Planning Area is dominated by Grass Rangeland, which comprises 46.39 percent of the total area. Other major LULC types in the combined planning area include Evergreen Forest (29.72%) and Crop/Pasture (15.03%).

The same three LULC types that dominate the planning areas also comprise the majority of the Upper and Lower Jefferson Planning Areas individually; however the upper and lower planning areas differ slightly in the distribution of LULC types. The Upper Jefferson is dominated by Evergreen Forest (40.83%), which tends to occur at higher elevations in the watershed. Grass Rangeland comprises an additional 37.76 percent of the Upper Jefferson, and Crop/Pasture represents an additional 11.86 percent of the area. The Lower Jefferson Planning Area is

dominated by Grass Rangeland (56.92%), with an additional 18.90 percent made up of Crop/Pasture and 16.16 percent of Evergreen Forest.

Table 13. Land Use and Land Cover in the Jefferson River Planning Areas

LULC Category	Upper Jefferson		Lower Jefferson		Combined Total		
	Acres	%	Acres	%	Acres	%	Cum %
Grass rangeland	177,529	37.76	219,439	56.92	396,968	46.39	46.39
Evergreen forest	191,974	40.83	62,308	16.16	254,282	29.72	76.11
Crop/pasture	55,737	11.86	72,856	18.90	128,593	15.03	91.14
Brush rangeland	14,597	3.10	19,159	4.97	33,756	3.95	95.08
Mixed forest	13,124	2.79	0	0.00	13,124	1.53	96.62
Mixed rangeland	12,554	2.67	336	0.09	12,890	1.51	98.12
Grass tundra	0	0.00	3,483	0.90	3,483	0.41	98.53
Shrub tundra	1,055	0.22	2,424	0.63	3,479	0.41	98.94
Bare tundra	540	0.11	1,847	0.48	2,388	0.28	99.22
Transportation/util	1,221	0.26	843	0.22	2,064	0.24	99.46
Reservoir	294	0.06	915	0.24	1,209	0.14	99.60
Wetland	0	0.00	765	0.20	765	0.09	99.69
Lake	590	0.13	84	0.02	675	0.08	99.77
Residential	330	0.07	224	0.06	554	0.06	99.83
Mines/quarries	58	0.01	266	0.07	324	0.04	99.87
Mixed urban/built-up	0	0.00	276	0.07	276	0.03	99.90
Exposed rock	214	0.05	0	0.00	214	0.03	99.93
Other urban/built-up	46	0.01	138	0.04	184	0.02	99.95
Commercial/services	124	0.03	60	0.02	184	0.02	99.97
Transitional	148	0.03	0	0.00	148	0.02	99.99
Confined feeding	0	0.00	94	0.02	94	0.01	100.00
Other ag	6	0.00	0	0.00	6	0.00	100.00
Totals	470,142	100.0	385,517	100.0	855,659	100.0	

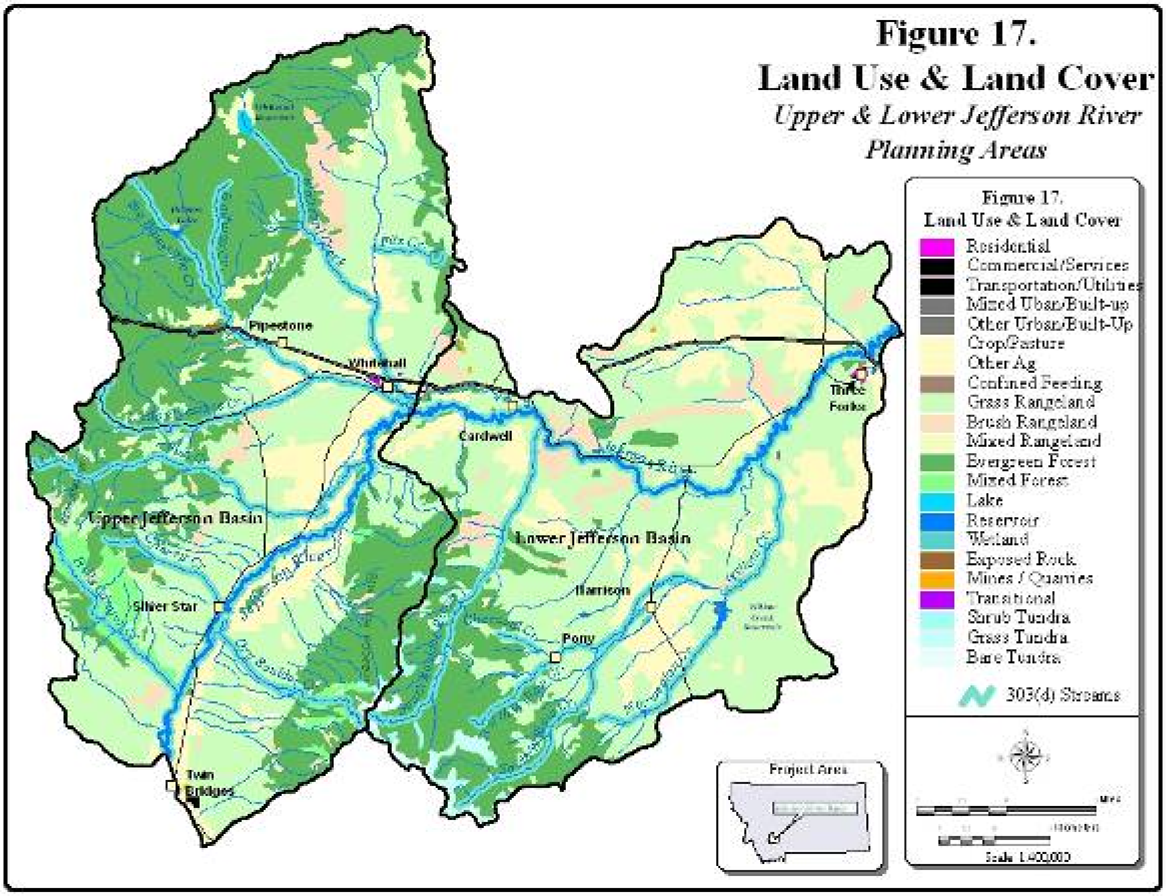


Figure 17. Land Use and Land Cover

1.1.11 Geology

Twelve USGS geologic mapping units occur within the Jefferson River Planning Areas (**Figure 18**). Four of these geologic units comprise more than 80 percent of the combined planning area: mixed miogeosynclinal rocks, calc-alkaline intrusive rocks, granitic gneiss, and alluvium (**Table 14).**

Mixed miogeosynclinal rocks, which are mostly sedimentary in nature, comprise 29.2 percent of the combined planning areas and are a dominant feature in the lower elevations of the watershed through the Jefferson River Valley, the lower reaches of Little Whitetail Creek, and in two large swaths south and west of Three Forks. Calc-alkaline intrusive geology is associated with the Boulder Batholith and is dominant in the higher elevation forested areas of the watershed, including the headwaters of Willow Creek in the Tobacco Root Mountains as well as the headwaters of Hells Canyon, Fish, Little Pipestone, Halfway and Whitetail Creeks in the Deerlodge National Forest. Granitic Gneiss comprises another 15.5 percent of the watershed and occurs mainly west of Silver Star, in the South Boulder River Valley, and north of Willow Creek Reservoir. Alluvium comprises 10.7 percent of the watershed, occurring predominately in the current and historic floodplains of the Jefferson River and its major tributaries.

These four geologic mapping units dominate in both the Upper and Lower Jefferson Planning Areas, individually and collectively for the combined planning areas, although the proportions of each differ slightly as shown in **Table 14**. The remaining 7 percent of the combined planning areas is a mixture of small areas of the several remaining geologic mapping units.

Geologic information was obtained from the USGS Major Lithology Database, available at: http://www.icbemp.gov/spatial/min/.

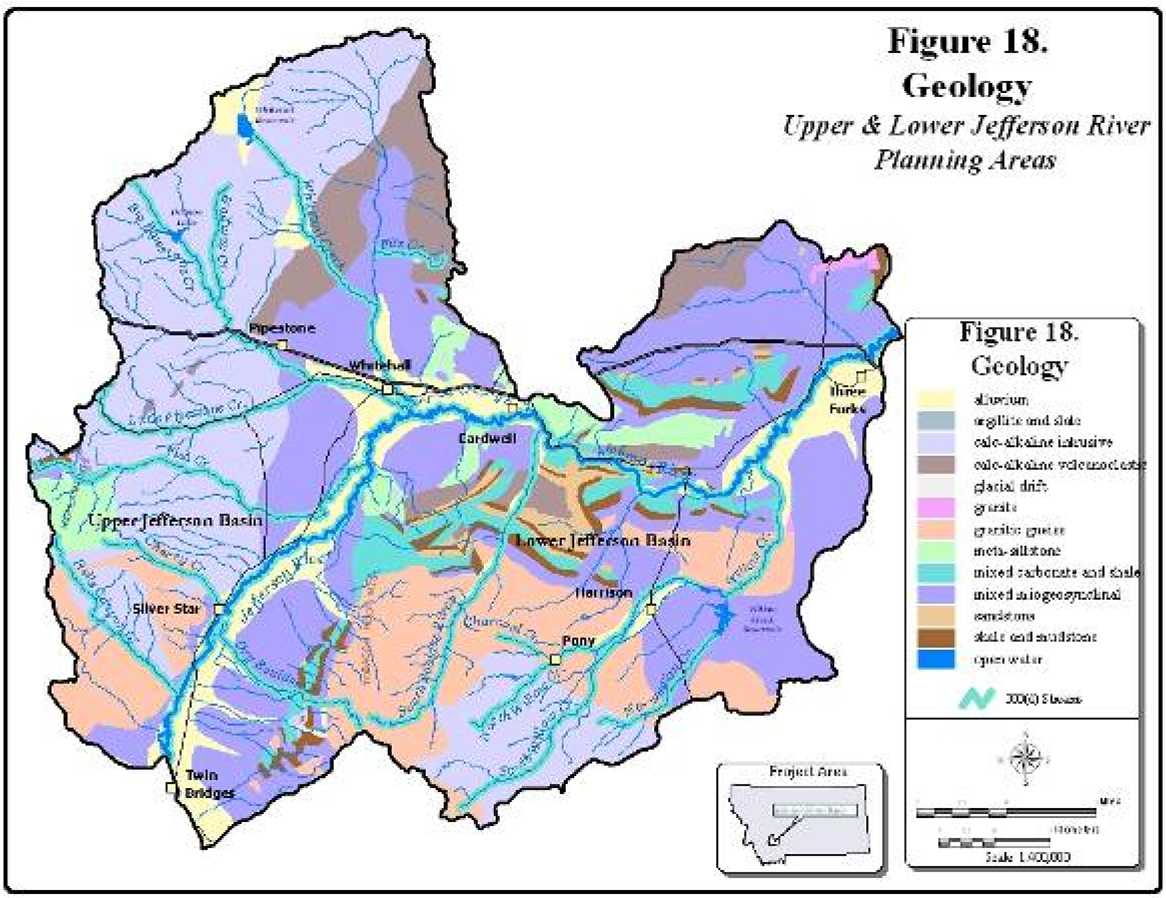


Figure 19. Geology

Table 14. Geology of the Jefferson River Planning Areas

Geologic Unit Code	Square Miles (% of Planning Area)	USGS Definition
Mixed miogeosynclinal rocks	Upper: 22.6 Lower: 37.2 Combined: 29.2	Mixed sequences of miogeosynclinal sedimentary rocks. Includes interlayered shale, siltstone, lithic sandstone, quartzite, and conglomerate.
Calc-alkaline intrusive rocks	Upper: 39.9 Lower: 10.7 Combined: 26.7	Calc-alkaline suite of intrusive rocks. Generally granodiorite to diorite.
Granitic gneiss	Upper: 10.9 Lower: 21.1 Combined: 15.5	Dominantly granitic gneiss, migmatite, augen gneiss, and hornblende gneiss. Includes subordinate anorthosite, amphibolite, calc-silicate gneiss, schist, marble, and quartzite.
Alluvium	Upper: 11.7 Lower: 9.5 Combined: 10.7	Unconsolidated sediment (clay, silt, sand, gravel). Includes glacial outwash deposits
Calc-alkaline volcanic rocks	Upper: 7.6 Lower: 4.4 Combined: 6.2	Calc-alkaline suite of pyroclastic rocks and volcanic flows. Generally andesite to quartz-latite.
Carbonate and shale	Upper: 2.5 Lower: 5.7 Combined: 3.9	Mixed sequences of carbonate rock and shale with subordinate sandstone and conglomerate
Meta-siltstone	Upper: 3.1 Lower: 3.9 Combined: 3.5	Fine-grained metamorphic rock formed from siltstone
Shale and mudstone	Upper: 1.4 Lower: 3.5 Combined: 2.3	Fine-grained sedimentary rock derived from clay
Sandstone	Upper: 0.2 Lower: 3.4 Combined: 1.6	Medium-grained detrital sedimentary rock derived from sand
Granite	Upper: 0.0 Lower: 0.5 Combined: 0.2	Includes intrusive rhyolitic rocks
Open water	Upper: 0.2 Lower: 0.2 Combined: 0.2	areas of water
Glacial drift	Upper: 0.1 Lower: 0.0 Combined: 0.05	Material deposited by glacial processes. Includes till and moraine (unstratified) as well as outwash (stratified).

1.1.12 Soils

Thirty-nine soil groups occur within the Jefferson River Planning Areas, and eleven soil groups account for two thirds of the area (**Table 15** and **Figure 19**). A complete list of soil types is found in **Attachment D**. Soils are predominantly deep, well-drained soils with loamy textures. Soils that form in alluvium tend to be sandy, while those that form in colluvium tend to be coarse. Parent materials vary throughout the planning area and include sedimentary, igneous, and metamorphic rocks. All soils data were obtained from the United States Department of Agriculture's State Soil Geographic database, available at: http://water.usgs.gov/GIS/metadata/usgswrd/ussoils.html.

The major soil series (Cowood-Hanks-Comad) are typically very deep, excessively drained sandy loams formed from gneiss, schist, and granitic rock. The Crago series is a very deep, well-drained loam derived mainly from limestone or conglomerate. The Garlet and Sebud series are very deep, well-drained, stony loam soils formed in till uplands, foot slopes, and in mountain valleys. The Nuley Series are deep, well-drained loamy soils formed on hills and bedrock floored plains.

Table 15. Major Soil Series within the Jefferson River Planning Areas

Map Unit Name	Acres	%	Cum %
Cowood-Hanks-Comad (MT140)	111,496.6	13.0	13.0
Sappington-Amesha-Crago Variant (MT012)	72,881.8	8.5	21.5
Varney-Nuley-Rock Outcrop (MT432)	70,441.6	8.2	29.8
Garlet-Rock Outcrop-Cryoborollis (MT485)	46,630.9	5.4	35.2
Orofino-Poin-Sebud (MT434)	45,874.8	5.4	40.6
Scravo-Grago-Musselshell (MT529)	42,410.4	5.0	45.5
Crittenden-Twilight Family-Castner (MT149)	41,964.4	4.9	50.5
Brocko-Kalsted-Crago (MT066)	41,530.3	4.9	55.3
Rivra-Bardwell-Ryell (MT477)	41,345.7	4.8	60.1
Brocko-Amesha-Crago Variant (MT063)	33,432.0	3.9	64.0
Rencot-Lahood-Rock Outcrop (MT469)	31,432.2	3.9	67.7

Soils in the Jefferson River Planning Areas are relatively fine grained, with approximately 78 percent of the combined area having clay contents ranging from 15 to 30 percent (**Table 16, Figure 20**). These fine-grained soils are typically found in the valleys and plains areas. An additional 21.1 percent of the combined planning areas have a clay content from 10 to 15 percent, with these areas concentrated in the mountainous regions. Soils with clay contents of 30 to 40 percent account for only 0.8 percent of the combined planning areas, and these are concentrated near the North/South Willow Creek confluence in the Lower Jefferson Planning Area.

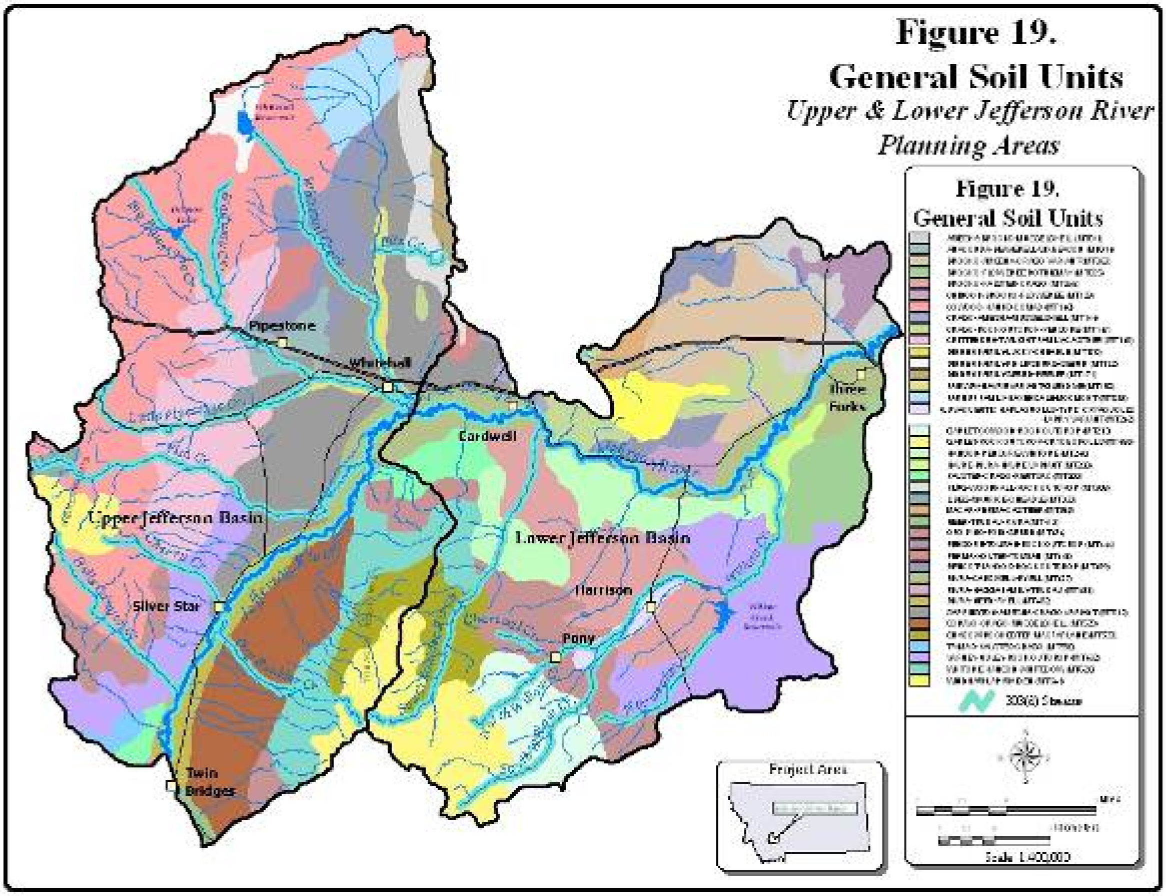


Figure 19. General Soil Units

Table 16. Soil Clay Content in the Jefferson River Planning Areas

Max Clay Content (%)	Upper Jefferson		Lower Jefferson		Combined Total	
	Acres	%	Acres	%	Acres	%
10 to <15	139,520	29.7	41,152	10.7	180,672	21.1
15 to <30	328,960	70.0	339,200	88.0	668,160	78.1
30 to <40	1,446	0.3	5,056	1.3	6,502	0.8
Totals	469,926	100.00	385,408	100.00	855,334	100.00

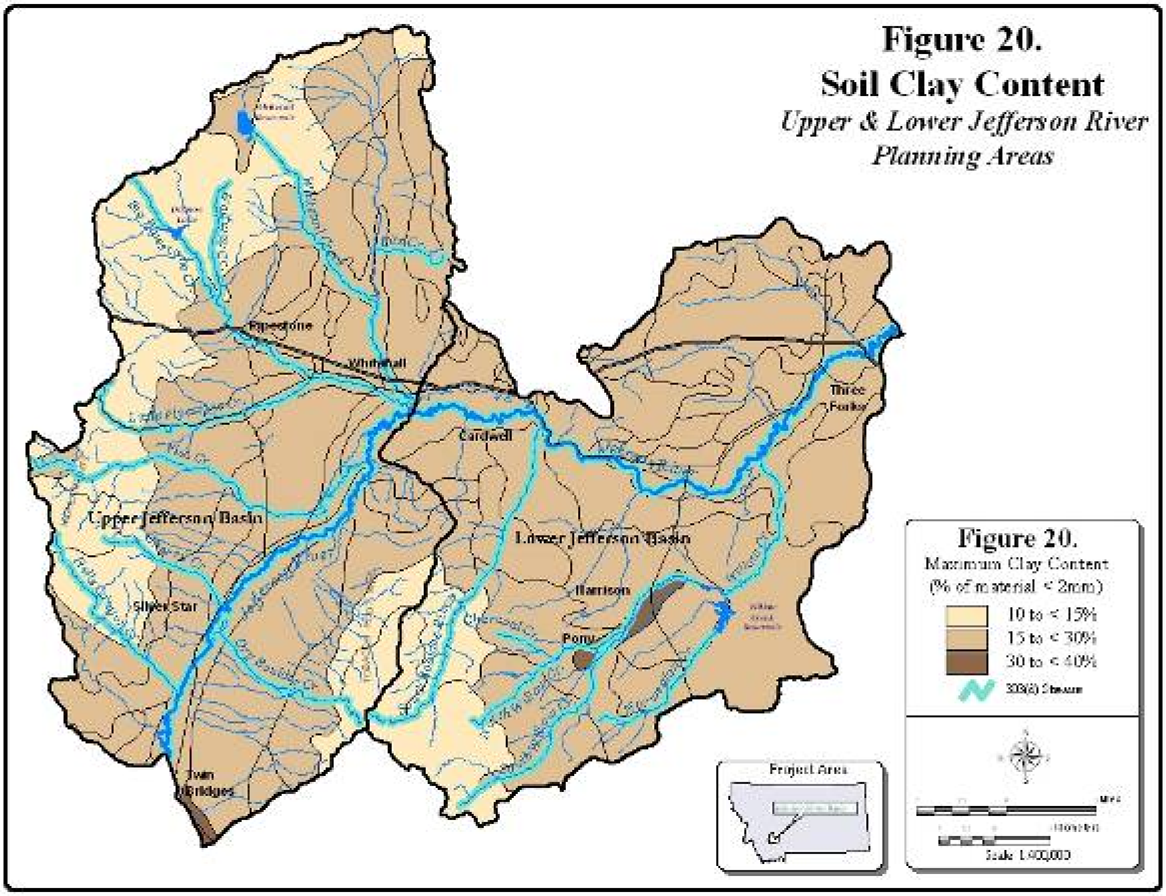


Figure 20. Soil Clay Content

Weighted-average minimum soil permeability was between 0.6 and 2 inches per hour in greater than 64 percent of the combined planning areas (**Table 17, Figure 21**). Permeability of various soil horizons can be more variable than this average figure, but is generally below 0.6 and 2 in/hr throughout most of the planning area.

Table 17. Soil Permeability in the Jefferson River Planning Areas

Minimum Permeability (in/hr)	Upper Jefferson		Lower Jefferson		Combined Total	
	Acres	%	Acres	%	Acres	%
0.2 to < 0.6	79,744	17.0	108,096	28.0	187,840	22.0
0.6 to < 2	274,752	58.4	277,440	72.0	552,192	64.5
2 to < 6	115,648	24.6	0	0	115,648	13.5
Totals	470,144	100.00	385,536	100.00	855,680	100.00

Surface soil salinity is generally low, with the majority of the combined planning area (96.2%) having salinity values of less than 1 mmhos/cm (**Table 18, Figure 22**). A few areas of higher

salinity occur along the Jefferson River between Twin Bridges and Whitehall, in the lower reaches of Whitetail and Pipestone Creeks, and in the vicinity of lower Willow Creek.

Table 18. Soil Salinity in the Jefferson River Planning Areas

Maximum Salinity (mmhos/cm)	Upper Jefferson		Lower Jefferson		Combined Total	
	Acres	%	Acres	%	Acres	%
Less than 1	443,136	94.3	379,776	98.5	822,912	96.2
1 to < 2	122	0.01	0	0.0	122	0.01
2 to < 3	7,424	1.6	63	0.01	7,487	0.9
3 to < 4	0	0.0	0	0.0	0	0.0
4 to <8	17,920	3.8	5,696	1.5	23,616	2.8
8 or more	1,446	0.3	0	0.0	1,446	0.2
Totals	470,048	100.00	385,535	100.00	855,583	100.00

The Universal Soil Loss Equation K-factor is a measure of a soil's inherent susceptibility to erosion by rainfall and runoff. Values of K range from 0 to 1, with higher numbers indicative of greater erosive potential.
Soils high in clay have low K values, about 0.05 to 0.15, because they are resistant to detachment. Coarse textured soils such as sandy soils have low K values, about 0.05 to 0.2, because of low potential for runoff, even though these soils are easily detached. Medium textured soils such as the silty loam soils have moderate K values, about 0.25 to 0.4, because they are moderately susceptible to detachment and they produce moderate runoff. Soils with high silt content are the most erodible of all soils. They are easily detached and tend to crust and produce high rates of runoff. Values of K for these soils tend to be greater than 0.4 (Michigan State University 2002).

The soil erosion K factor is moderate throughout most of the Jefferson Planning Area, with 48.7 percent of the area characterized by K factors in the 0.3 – 0.4 range, and 46.0 percent characterized by K factors in the 0.2 – 0.3 range. Soil erosion K factors are slightly higher in the Lower Jefferson area, where the majority of soils (61.6%) are in the 0.3 – 0.4 range, than in the Upper Jefferson area, where the majority of soils (58.0%) are in the 0.2 – 0.3 range (**Table 19, Figure 23**).

Table 19. Soil Erosion K factor in the Jefferson River Planning Areas

Weighted K Factor	Upper Jefferson		Lower Jefferson		Combined Total	
	Acres	%	Acres	%	Acres	%
0.1 to < 0.2	18,522	3.9	27,354	7.1	45,876	5.4
0.2 to < 0.3	272,557	58.0	120,621	31.3	393,178	46.0
0.3 to < 0.4	179,027	38.1	237,536	61.6	416,563	48.7
Totals	470,106	100.00	385,511	100.00	855,617	100.00

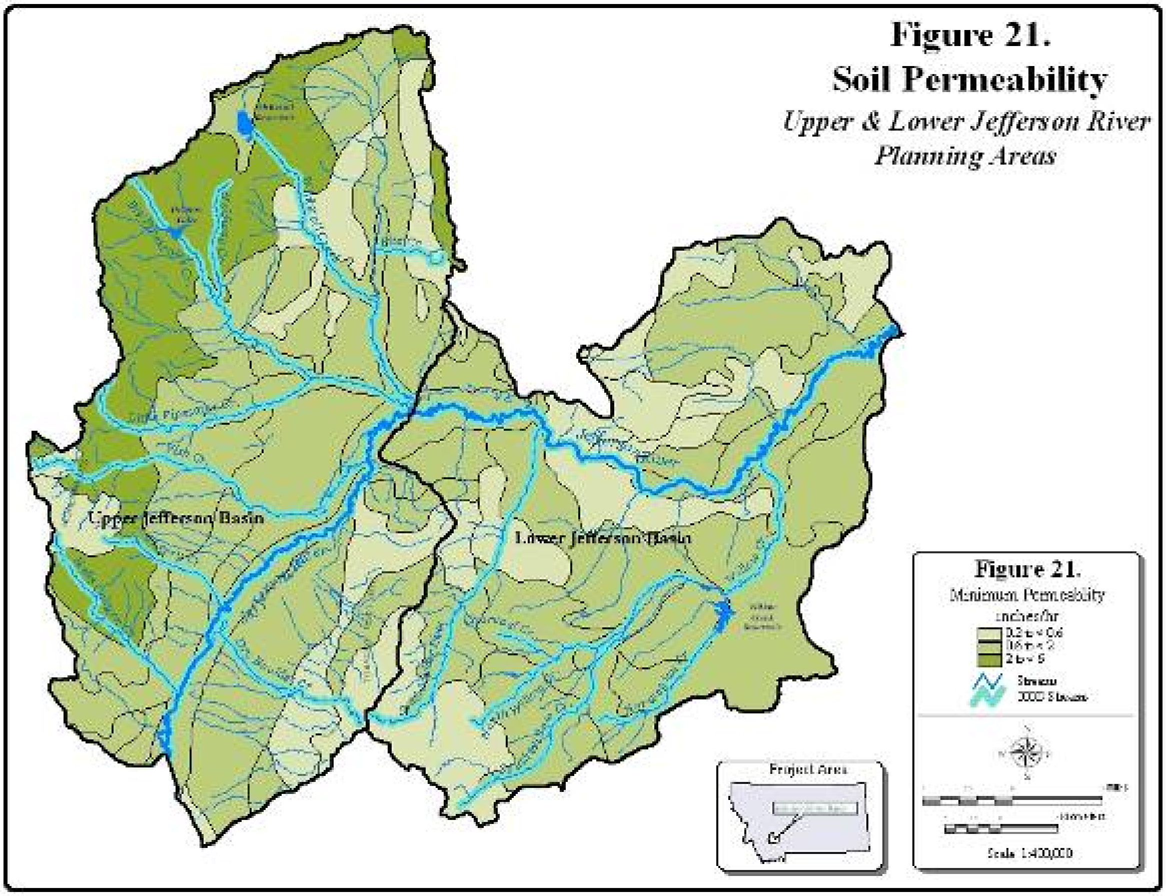


Figure 21. Soil Permeability

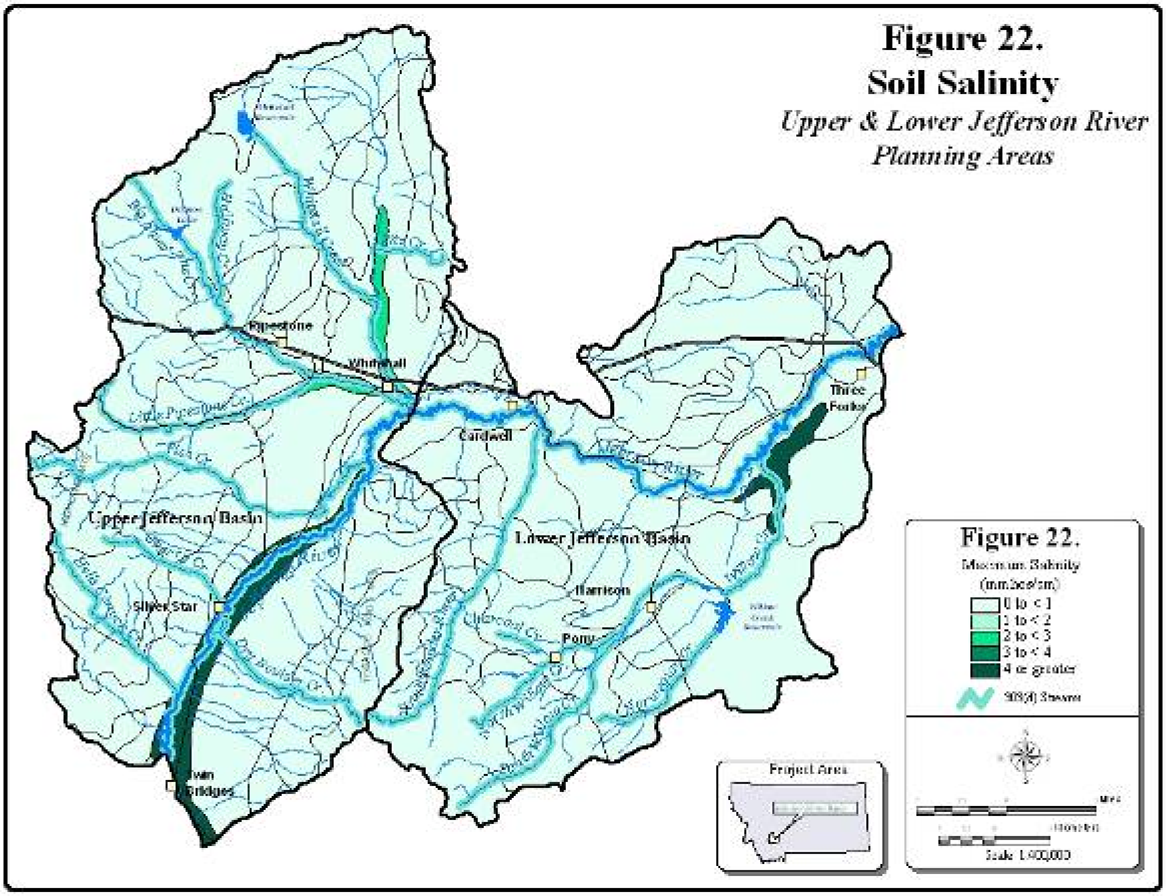


Figure 22. Soil Salinity

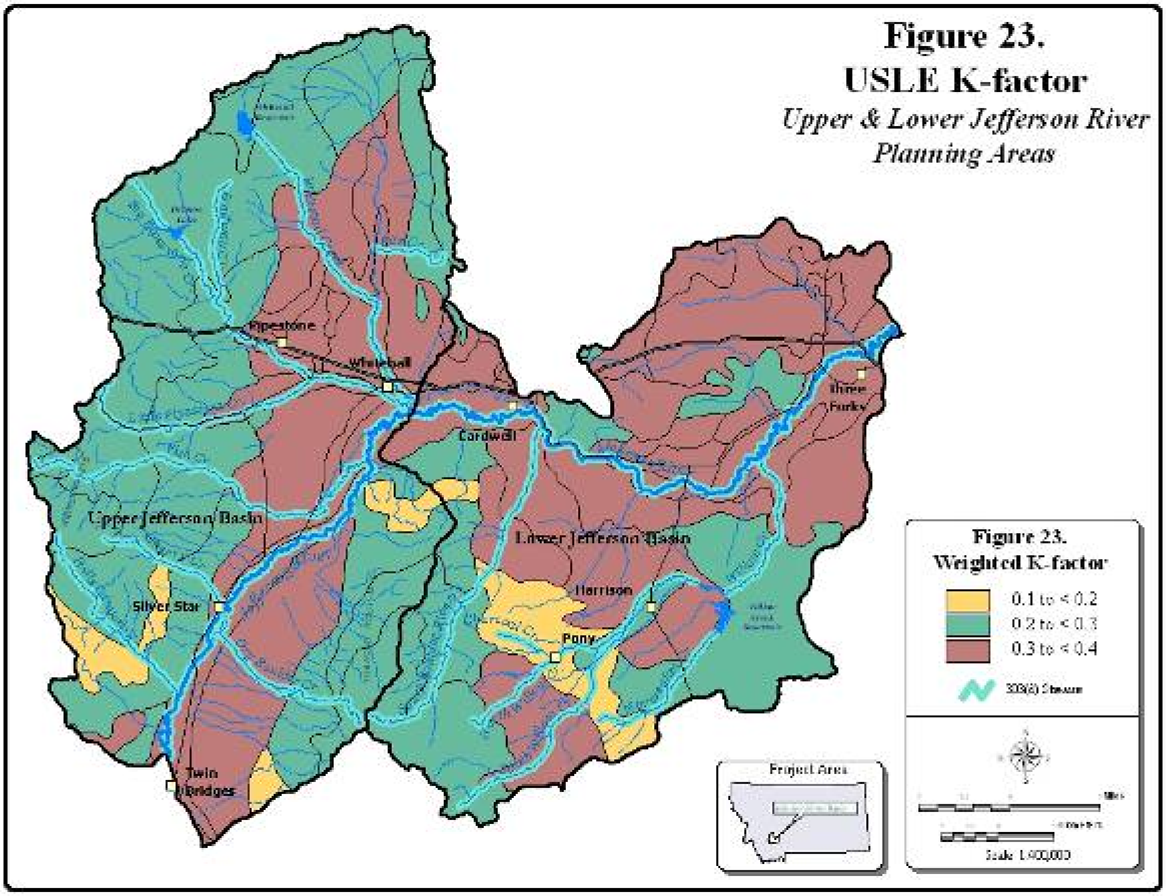


Figure 23. USLE K-factor

1.1.13 Mineral Extraction and Mining

The Montana Bureau of Mines and Geology database (http://nris.state.mt.us/nsdi/nris/ms4.html) lists 404 mineral extraction locations within the Jefferson River Planning Areas (**Figure 24**). Gold is the most common type of mine, accounting for slightly more than half of all listed mining operations. Other common mine types include lead, copper, zinc, iron, and tungsten. A complete listing of active and inactive mining locations is found in **Attachment E**.

1.1.14 Point Source Discharges

Six permitted point source wastewater discharges are located within the Jefferson River Planning Areas, including two municipal wastewater treatment system discharges, one industrial discharge, and three storm water outfalls (**Table 20, Figure 25**).

Table 20. Point Source Discharges

Permit Name	Type	Receiving Waterbody
Conda Mining, Inc.	Storm water	Pipestone Creek
Luzenac America, Inc.	Storm water	Creeklyn Ditch to Jefferson River
Twin Bridges (WWTP) 001	Municipal	Bayers Ditch to Jefferson River
Golden Sunlight Mine	Storm water	St. Paul Gulch to Whitehall Creek
Willow Creek Sewer District (WWTP) 001	Municipal	Unnamed irrigation ditch
Luzenac America, INC. (Talc Mill) 001	Industrial	Unnamed wetland

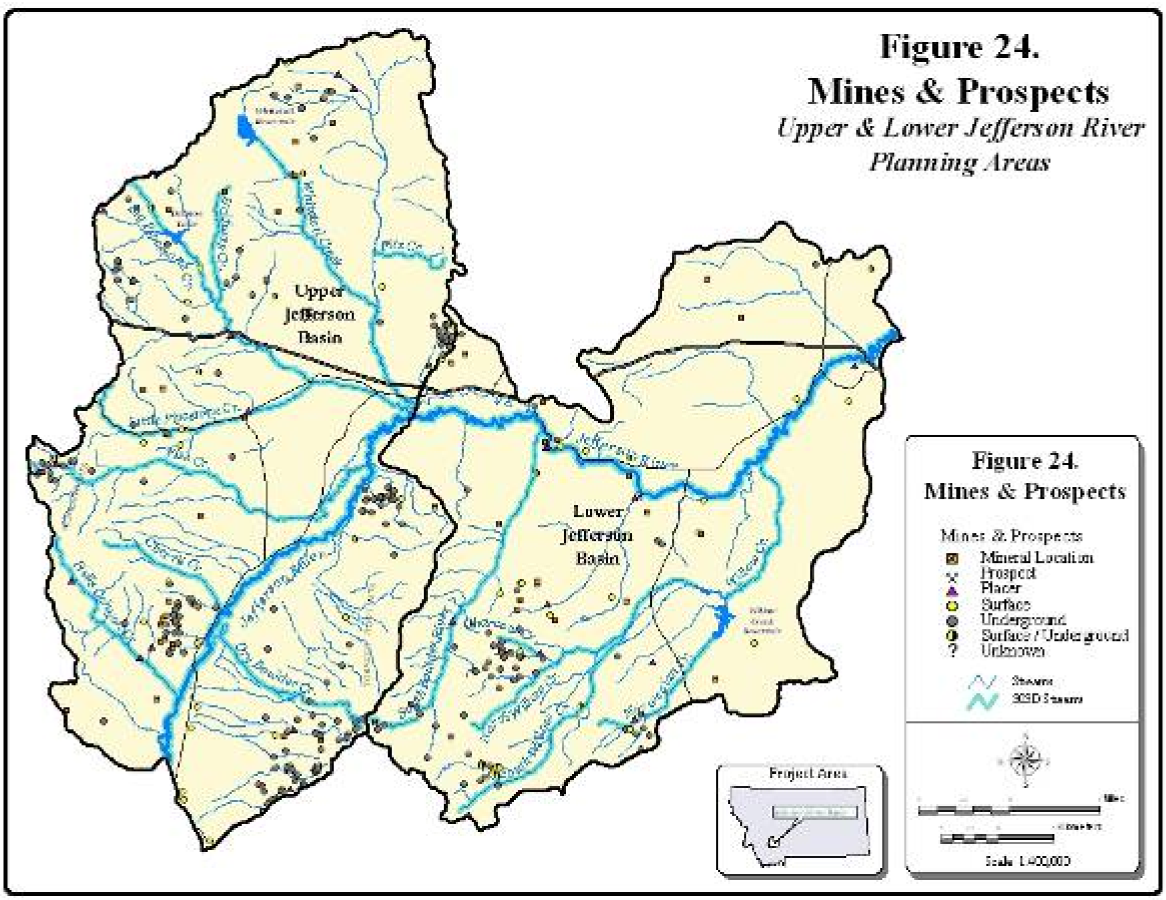


Figure 24. Mines and Prospects

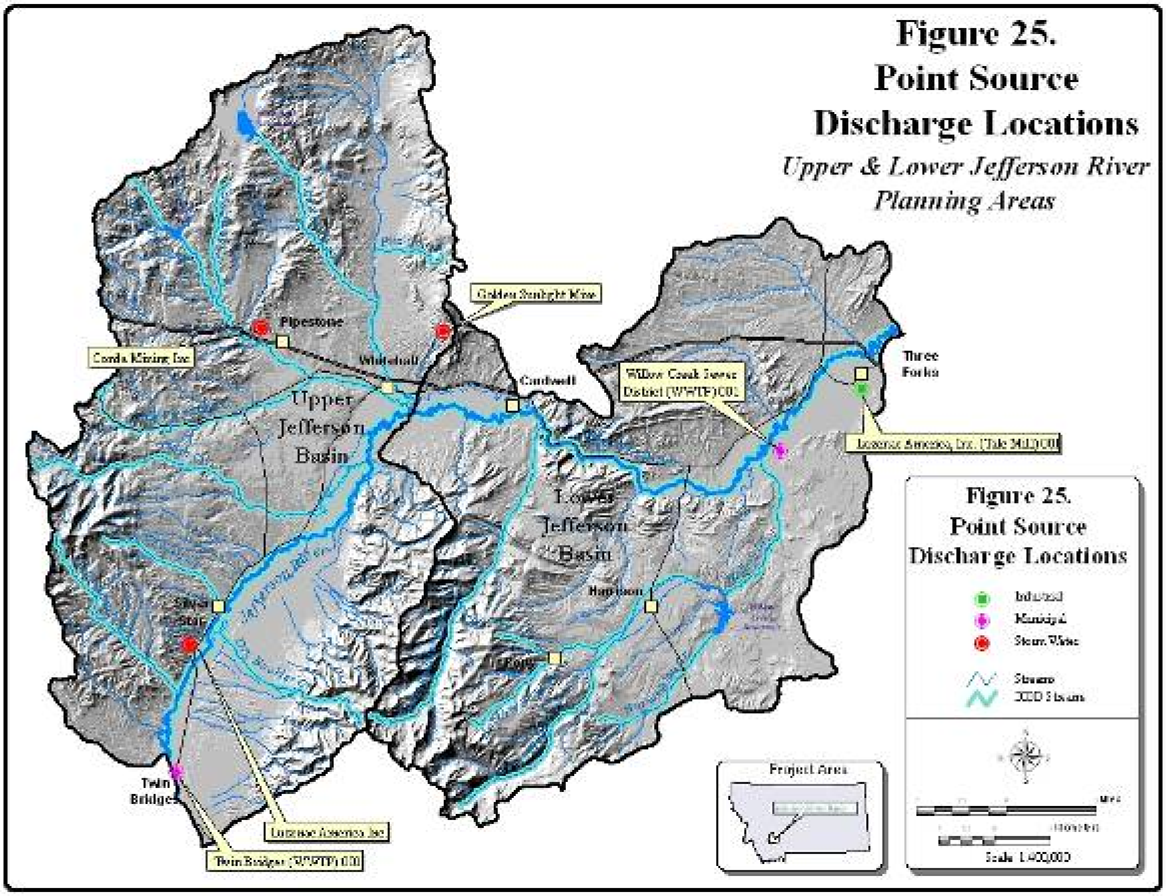


Figure 25. Point Source Discharge Locations

1.2 Fisheries

For the Jefferson River Planning Areas, two fish species, the westslope cutthroat trout (*Oncorhynchus clarki lewisi*) and the Montana Arctic grayling (*Thymallus arcticus montanus*) are listed by the State of Montana as species of special concern. According to Montana Fish, Wildlife and Parks fish distribution database, westslope cutthroat are limited to the Upper Jefferson River Planning Area, and are thought to occur in five streams, including four that appear on the 303(d) list. These include: Halfway Creek, Fish Creek, Cherry Creek, and Hells Canyon Creek. Cutthroat trout are also found in Mill Creek, which is not on the 303(d) list (**Figure 26**). Genetically pure populations of westslope cutthroat trout are thought to be limited to Halfway and Fish Creeks (Spoon pers. com. 2003). The present distribution of Montana Arctic grayling in the Jefferson watershed is unknown.

The status of these fish is described by Montana DEQ in the *Preliminary Assessment Report for the Upper Jefferson River* (MDEQ 2002b), excerpted here. *Westslope cutthroat trout (Oncorhynchus clarki lewisi) are present in the Upper Jefferson Planning Area. Westslope cutthroat trout is listed on the State of Montana's list of Animal Species of Special Concern*

(Carlson 2001) with a state rank of S2. An "S2" rank is described as "imperiled because of rarity or because of other factors demonstrably making it very vulnerable to extinction throughout its range". It is also listed as "sensitive" by the USFS ("animal species … for which population viability is a concern as evidenced by significant downward trend in population or a significant downward trend in habitat capacity") and "special status" by the BLM ("federally-listed Endangered, Threatened, or Candidate species or other rare or endemic species that occur on BLM lands").

Montana Arctic grayling (Thymallus arcticus montanus) might be present in the Jefferson River as a result of an attempt to reestablish a population in the lower Beaverhead River upstream of the confluence of the Beaverhead and Big Hole Rivers. Fluvial grayling are known to move great distances upstream and downstream in response to water temperature increases, seasonal habitat preferences and runoff. The grayling is on the State of Montana's list of Animal Species of Special Concern with a state rank of S1. An "S1" rank is described as "critically imperiled because of extreme rarity or because of some factor(s) of its biology making it especially vulnerable to extinction". It is also listed as "sensitive" by the USFS ("animal species … for which population viability is a concern as evidenced by significant downward trend in population or a significant downward trend in habitat capacity") and is a candidate species for listing under the federal Endangered Species Act of 1973 (Carlson 2001). Candidate species are described as those that the US Fish and Wildlife Service has sufficient information on biological status and threats to propose to list them as threatened or endangered (MDEQ 2002b).

The Jefferson River sport fishery is dominated by brown trout. Rainbow trout are also present, comprising an estimated 10% of the of the trout population in 1989; however the proportion of rainbow trout has risen to an estimated 45% of the population in the Jefferson above Whitehall and 10 to 20% below Whitehall in response, at least in part, to improved spawning in Hell's Canyon and Willow Springs Creeks (MFWP 1989; Rehwinkel pers. com. 2003; Spoon pers. com. 2003). Biologists from the Montana Fish, Wildlife, and Parks have estimated that the Jefferson can support a potential brown trout population of 600 fish two years old and older per mile. However, in recent years, the population has dropped below 200 brown trout per mile. The most likely explanation of the decline is the series of extremely low flow years that have occurred in the Jefferson since the late 1980s, and the elevated stream temperatures that have resulted from these low streamflows (Spoon pers. com. 2003). The Jefferson's brown trout fishery is also potentially hampered by a lack of suitable spawning habitat, particularly in Jefferson River tributaries. The vast majority of spawning of Jefferson River browns is thought to occur in the lower Ruby and the lower Boulder Rivers. Rainbow trout spawning habitat, while still limited, has improved in recent years in response to restoration efforts in Hells Canyon and Willow Springs Creeks (Rehwinkel pers. com. 2003).

Fortunately, efforts are currently underway to improve the Jefferson's fishery. For example, the Jefferson River Watershed Council has worked with state and federal agencies and local citizens to develop a drought management plan to reduce the effects of low flow on the Jefferson's fishery (JRWC 2000), and Trout Unlimited is working with local landowners to improve streamflow spawning habitat in the Willow Creek drainage, a tributary to the Jefferson (Rehwinkel pers. com. 2003).

Fisheries mapping information was obtained from the Montana Fish, Wildlife and Parks Fish Distribution Database, available at:
http://fwp.state.mt.us/insidefwp/fwplibrary/gis/metadata/Fishdist.htm.

1.3 Orthophoto Quadrangle Maps

A digital orthophoto quad map for the Jefferson River Planning Areas is presented in **Figure 27**.

1.4 Water Quality Monitoring Stations

A map of water quality monitoring locations represented in state and federal water quality databases is presented in **Figure 28** and a list of the station locations is included in **Attachment F**. Databases reviewed for presence of monitoring information in the Jefferson watershed include Montana DEQ's former Storease water quality data system, the USGS National Water Information System, and U.S. EPA's national STORET water quality database. The USGS and STORET databases are available at http://waterdata.usgs.gov/nwis/ and http://www.epa.gov/STORET/dbtop.html. Water quality data for selected Jefferson watershed monitoring locations are summarized in the *Jefferson Watershed Water Quality Status Report*, which is a companion report to this watershed characterization.

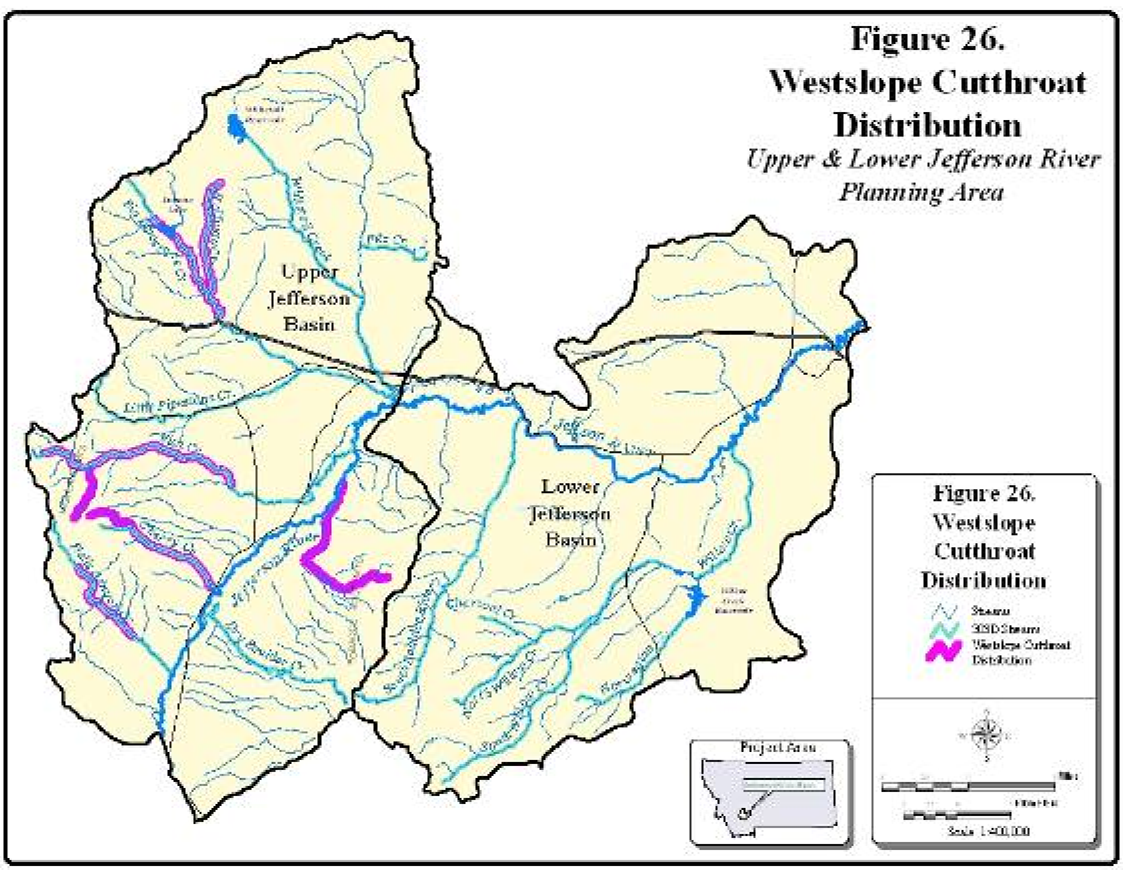


Figure 26. Westslope Cuttthroat Distribution

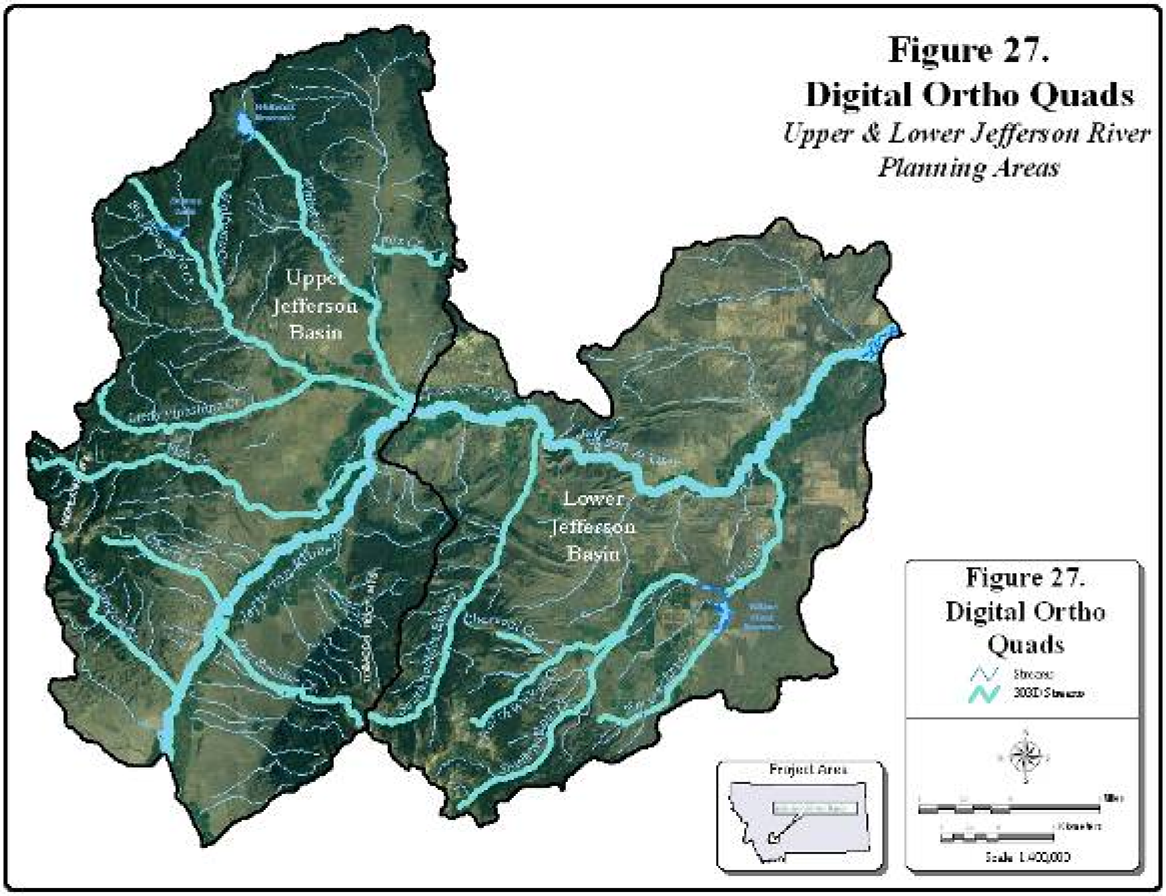


Figure 27. Digital Ortho Quads

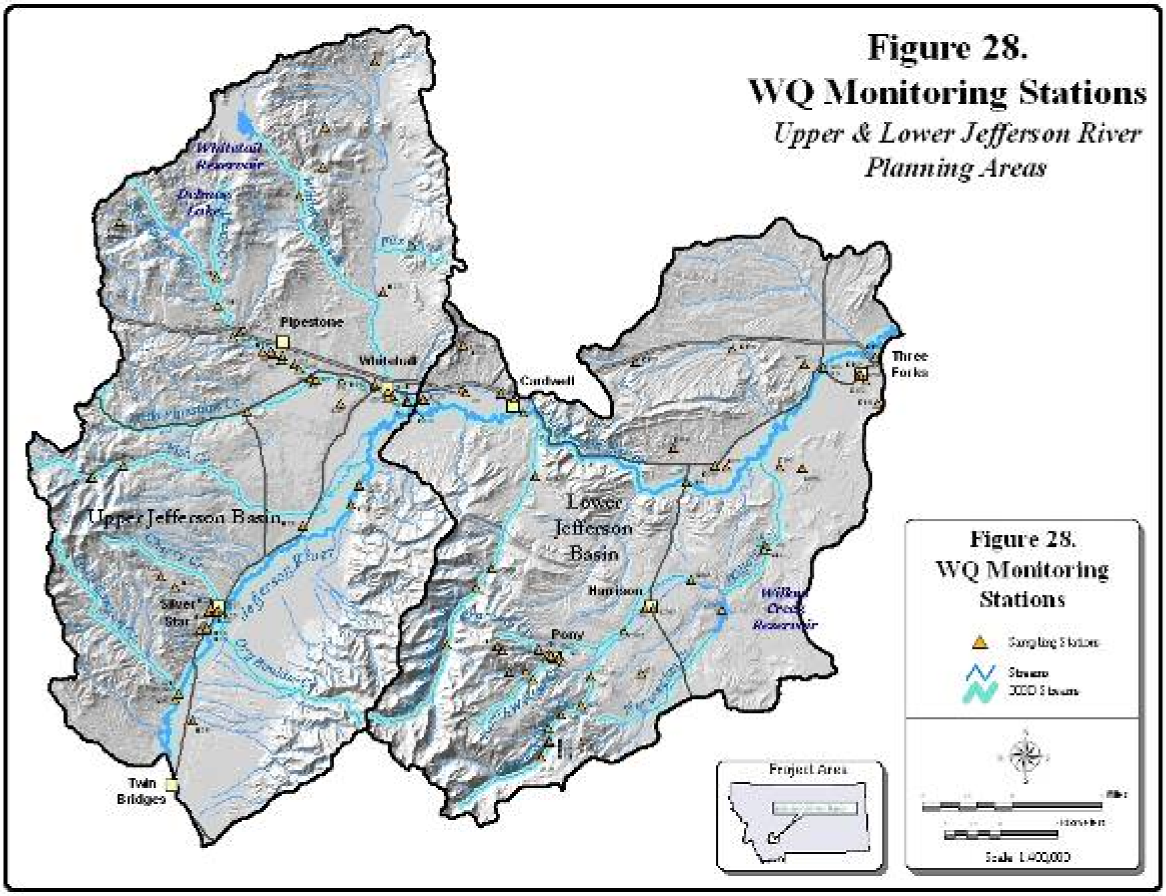


Figure 28. WQ Monitoring Stations

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ATTACHMENT A
SUMMARY CLIMATIC DATA FOR SELECTED NOAA STATIONS, JEFFERSON RIVER PLANNING AREAS

Summary Climatic Data for Selected NOAA Stations.

Station	NOAA Station	Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Twin Br	248430	Average Max. Temperature (F)	34	40	47	57	67	75	84	82	72	61	44	35	58.2
Pony	246655	Average Max. Temperature (F)	33	37	43	52	61	69	78	77	67	56	41	34	54.1
Norris	246153	Average Max. Temperature (F)	34	40	44	55	65	74	85	84	72	61	45	38	58
Twin Br	248430	Average Min. Temperature (F)	11	15	20	28	36	42	46	43	35	27	19	12	27.8
Pony	246655	Average Min. Temperature (F)	12	16	20	28	36	43	49	47	39	31	20	14	29.6
Norris	246153	Average Min. Temperature (F)	12	19	21	29	35	43	45	44	36	31	22	17	29.4
Twin Br	248430	Average Total Snowfall (in.)	2	2.4	2.8	0.9	0.1	0	0	0.1	0	0.3	1.4	1	11
Pony	246655	Average Total Snowfall (in.)	10	9.5	17	13	3.3	0.2	0	0.1	2.8	7.3	11	11	85.8
Norris	246153	Average Total Snowfall (in.)	7.9	6.3	17	7.8	1.8	0	0	0	0.9	1.7	8.3	6.8	58.3
Twin Br	248430	Average Total Precipitation (in.)	0.3	0.2	0.5	0.9	1.7	1.9	1.1	1	1	0.6	0.4	0.3	9.65
Pony	246655	Average Total Precipitation (in.)	0.7	0.6	1.4	2	3.1	2.7	1.5	1.4	1.7	1.4	1	0.7	18.02
Norris	246153	Average Total Precipitation (in.)	0.4	0.4	1.1	1.6	2.8	2.9	1.1	1.1	1.8	1.5	0.8	0.3	15.91

Period of Record: Norris (1957 to 1982), Pony (1959 to 1998), Twin Bridges (1950 t0 2002)

ATTACHMENT B
USGS GAUGING STATIONS, JEFFERSON RIVER PLANNING AREAS

Table B-1. USGS Gauging Stations in the Jefferson River Planning Areas

Station Number	Station Name	Drainage Area (mi^2)	Period of Record
06026500	Jefferson River near Twin Bridges	7632	1940-1943, 1958-1972, 1994-Present
06027000	Jefferson River near Silver Star	7683	1910-1916, 1920-1939
06027200	Jefferson River at Silver Star	7683	1972-1974
06027500	Bell Creek near Waterloo	5.63	1941-1942
06027700	Fish Creek near Silver Star	38.9	1959-1991
06028000	Big Pipestone Creek near Whitehall	108	1910-1911
06028500	Little Pipestone Creek near Whitehall	30.7	1935-1940
06028700	Big Pipestone Creek at Whitehall		
06029000	Whitetail Creek near Whitehall	30.8	1949-1968
06029500	Little Whitetail Creek near Whitehall	91	1911
06030000	Whitetail Creek at Whitehall	179	1911
06030200	Jefferson River tributary near Whitehall	1.85	
06030300	Jefferson River tributary #2 near Whitehall	4.5	
06034000	South Boulder River near Jefferson Island	27.5	1926-1933
06034300	South Boulder River near Cardwell		
06034500	Jefferson River at Sappington	9277	1895-1905, 1938-1969
06034700	Sand Creek at Sappington	9.41	
06034800	Jefferson River tributary #3 near Sappington	1.14	
06035000	Willow Creek near Harrison	83.8	1938-Present
06035500	Norwegian Creek near Harrison	22.4	1938-1943, 1946-1951
06036500	Willow Creek near Willow Creek	165	1919-1933, 1946-1953, 1955-1957
06036600	Jefferson River tributary #4 near Three Forks	0.53	
06036650	Jefferson River near Three Forks	9532	1978-Present
06036700	Jefferson River tributary #5 near Three Forks	3.69	

ATTACHMENT C
MAJOR LAND RESOURCE AREAS (MLRAS), JEFFERSON RIVER PLANNING AREAS

Northern Rocky Mountains
Idaho, Montana, Oregon, Washington, and Wyoming
282,650 km^2 (109,130 mi^2)

Land use: Nearly all this area is federally owned and administered by the Forest Service, U.S. Department of Agriculture, and the Bureau of Land Management, Department of the Interior. Most of the privately owned land is controlled by large commercial timber companies. All the forested areas are used as wildlife habitat, for recreation and watershed, and for timber production. Meadows on the upper mountain slopes and crests above timberline provide summer grazing for livestock and big game animals. Mining is an important industry in Idaho and in western Montana. Dairy and livestock farms are important enterprises in the west. Less than 2 percent of the area is cropped. Forage, grain, peas, and a few other crops are grown in some valleys.

Elevation and topography: Elevation is mainly 400 to 2,400 m, but it is almost 3,000 m on some mountain peaks. Some areas in Montana and Wyoming are at an elevation of 2,100 to 3,000 m, and mountain peaks are almost 4,300 m. High mountains having steep slopes and sharp crests are cut by narrow valleys, most of which have steep gradients. Lakes are common, especially in glaciated areas.

Climate: *Average annual precipitation*: Mainly 625 to 1,525 mm, increasing with elevation, but almost 375 mm in the western part of the area and almost 2,550 mm in high mountains. Most of the precipitation during fall, winter, and spring is snow. Summers are dry. *Average annual temperature*: 2 to 7 C in most of the area, but it is 8 C or more at low elevations. *Average freeze-free period*: 45 to 120 days, decreasing with elevation, and as long as 140 days in low valleys of Washington. Frost occurs every month of the year on high mountains; some peaks have a continuous cover of snow and ice.

Water: Moderate precipitation and many perennial streams and lakes provide ample water. Streams and reservoirs supply water to adjoining MLRA's for irrigation and other uses. Springs and shallow wells in the valleys provide water for domestic use and for livestock. Elsewhere, ground-water supplies are small and mostly untapped.

Soils: Most of the soils are Ochrepts and Andepts. They have a frigid or cryic temperature regime. Shallow to moderately deep, medium textured and moderately coarse textured Cryochrepts (Jughandle and Holloway series) and Xerochrepts (Waits and Moscow series) are on mountain slopes. Cryandepts (Huckleberry, Truefissure, and Coerock series) are on ridges with thin layers of volcanic ash. Stony Cryorthents (Tamely series) and areas of rock outcrop are on peaks and ridges above timberline. Detailed soil survey information is lacking in most of the area.

Potential natural vegetation: This area supports conifer forests. Forests of western white pine, ponderosa pine, lodgepole pine, western redcedar, western larch, hemlock, Douglas-fir, subalpine fir, and spruce are common. Alpine grasses, forbs, and shrubs and scattered stands of subalpine fir, spruce, and whitebark pine grow on high mountains of Montana and Wyoming.

Northern Rocky Mountain Valleys
Idaho, Montana, and Washington
32,320 km^2 (12,480 mi^2)

Land Use: Nearly all this area is in farms and ranches. As much as one-third of the land in some valleys is irrigated. Potatoes, sugar beets, and peas are important cash crops, but a larger acreages in hay, grain, and pasture for livestock feed. In places where precipitation is adequate, the land is dry-farmed to wheat. One-third to one-half of the area is range of native grasses and shrubs. Beef cattle and sheep are the principal livestock, but dairying is an important enterprise near the larger towns. Much of the area in northern Idaho is forested, and elsewhere many steep and stony soils are in woodland. These forests are of value to the lumber industry and are also grazed.

Elevation and Topography: Elevation ranges from 600 to as much as 2,100 m; the highest is in south western Montana. The deep valleys bordered by mountains are mostly north-south trending. In the valleys, nearly level, broad flood plains are bordered by gently sloping to strongly sloping terraces and fans. In many places the valleys have been modified somewhat by glaciation, and in the north, lacustrine sediments cover much of the valley floors.

Climate: Average annual precipitation 300 to 400 mm in most of the area, less than 250 mm in Montana, and 850 mm in northern Idaho. Precipitation is fairly evenly distributed throughout fall, winter, and spring but is low in summer. Most of the precipitation in winter is snow. Average annual temperature 4 to 8 C. Average freeze-free period--100 to 120 days in much of the area, but it is 80 days or less at the highest elevations and 130 days or more at the lowest.

Water: Perennial streams flowing into the area from surrounding mountains are the principal source of water. The amount usually is adequate but depends on the snow accumulation in the mountains. Ground water is abundant in the deeper unconsolidated fill materials, and some is used for irrigation. Precipitation is adequate for some dryfarming at higher elevations and throughout the area in northern Idaho.

Soils: The dominant soils are mostly Orthids, Borolls, and Argids. They are medium textured to fine textured and mainly well drained and have a frigid or, at higher elevations, a cryic temperature regime. At the lower elevations, deep and moderately deep Calciorthids (Crago and Musselshell series), Haploborolls (Bitterroot and Grantsdale series), and Argiborolls (Martinsdale series) are on alluvial fans and terraces. Natrargids (Round Butte series) are on lacustrine fans and terraces, and Fluvents are on alluvial flood plains and low terraces. At the higher elevations, mostly deep, well drained to somewhat poorly drained Cryoborolls (Amsterdam, Bozeman, Bridger, and Gallatin series) are on alluvial terraces and fans, and Aquents and Aquepts are adjacent to drainageways and in undrained depressions.

Potential Natural Vegetation: This area supports conifer forests and grassland vegetation. Bluebunch wheatgrass, rough fescue, Idaho fescue, and bearded wheatgrass are the major species of the grassland in the valleys and foothills. Douglas-fir, ponderosa pine, grand fir, western redcedar, western hemlock, pinegrass, common snowberry, mallow ninebark, and white spirea are the major forest species.

ATTACHMENT D
SOIL SERIES OF THE JEFFERSON RIVER PLANNING AREAS, JEFFERSON RIVER PLANNING AREAS

Table D-1Soil Series of the Jefferson River Planning Areas

Soil Mapping Unit	Lower Jefferson (mi^2)	Lower Jefferson (%)	Upper Jefferson (mi^2)	Upper Jefferson (%)	Total (mi^2)	Total (%)
COWOOD-HANKS-COMAD (MT140)			174.21	23.7%	174.21	13.0%
SAPPINGTON-AMESHA-CRAGO VARIANT (MT012)	8.89	1.5%	104.99	14.3%	113.88	8.5%
VARNEY-NULEY-ROCK OUTCROP (MT432)	73.70	12.2%	36.36	5.0%	110.06	8.2%
GARLET-ROCK OUTCROP-CRYOBOROLLS (MT485)	43.42	7.2%	29.44	4.0%	72.86	5.4%
ORO FINO-POIN-SEBUD (MT434)	42.74	7.1%	28.94	3.9%	71.68	5.4%
SCRAVO-CRAGO-MUSSELSHELL (MT529)			66.27	9.0%	66.27	5.0%
CRITTENDEN-TWILIGHT FAMILY-CASTNER (MT149)			65.57	8.9%	65.57	4.9%
BROCKO-KALSTED-CRAGO (MT066)	64.89	10.8%			64.89	4.9%
RIVRA-CARDWELL-RYELL (MT477)	52.76	8.8%	11.84	1.6%	64.60	4.8%
BROCKO-AMESHA-CRAGO VARIANT (MT063)	52.24	8.7%			52.24	3.9%
RENCOT-LAHOOD-ROCK OUTCROP (MT469)	18.08	3.0%	31.03	4.2%	49.11	3.7%
WHITORE-HANSON-WHITECOW (MT628)	8.54	1.4%	38.25	5.2%	46.79	3.5%
HANSON-PENSORE-WHITORE (MT240)	43.13	7.2%			43.13	3.2%
SHADOW-ROCHESTER-MACFARLANE (MT533)	20.89	3.5%	14.55	2.0%	35.44	2.7%
GARLET-COWOOD-ROCK OUTCROP (MT213)	34.18	5.7%			34.18	2.6%

Table D-1Soil Series of the Jefferson River Planning Areas

Soil Mapping Unit	Lower Jefferson (mi^2)	Lower Jefferson (%)	Upper Jefferson (mi^2)	Upper Jefferson (%)	Total (mi^2)	Total (%)
RIVRA-NEEN-RYELL (MT482)			28.04	3.8%	28.04	2.1%
BROCKO-FLOWEREE-ROTHIEMAY (MT065)	24.64	4.1%			24.64	1.8%
CRAGO-ROCK OUTCROP-PENSORE (MT147)	22.33	3.7%	1.09	0.1%	23.42	1.8%
FARNUF FAMILY-BAXENDALE-MOCMONT (MT033)			21.68	3.0%	21.68	1.6%
KLUG-WOODHALL-ROCK OUTCROP (MT308)	1.13	0.2%	19.27	2.6%	20.40	1.5%
AMESHA-BROCKO-MUSSELSHELL (MT011)	18.79	3.1%			18.79	1.4%
KALSTED-CRAGO-RENTSAC (MT300)	10.55	1.8%	7.82	1.1%	18.36	1.4%
WINDHAM-LAP-MAIDEN (MT641)	13.37	2.2%			13.37	1.0%
PENSORE-TOLMAN-ROCK OUTCROP (MT444)	11.98	2.0%			11.98	0.9%
FAIRWAY-HAVRE VARIANT-GLENDIVE (MT192)	0.10	0.0%	11.64	1.6%	11.74	0.9%
ANACONDA-BEAVERELL-SIXBEACON (MT014)			11.33	1.5%	11.33	0.8%
PERMA-HOLTER-TOLMAN (MT448)	2.21	0.4%	8.15	1.1%	10.36	0.8%
HAVRE-RIVRA-HAVRE VARIANT (MT260)	8.90	1.5%			8.90	0.7%
CHINOOK-BROCKO-FLOWEREE (MT129)	8.11	1.3%			8.11	0.6%
DINNEN FAMILY-PHILIPSBURG-SEBUD (MT172)			7.91	1.1%	7.91	0.6%
FLUVAQUENTIC HAPLAQUOLLS-TYPIC CRYAQUOLLS-LARRY VARIANT (MT242)	7.90	1.3%			7.90	0.6%

Table D-1Soil Series of the Jefferson River Planning Areas

Soil Mapping Unit	Lower Jefferson (mi^2)	Lower Jefferson (%)	Upper Jefferson (mi^2)	Upper Jefferson (%)	Total (mi^2)	Total (%)
MACAR-PERMA-CASTNER (MT363)	6.89	1.1%			6.89	0.5%
DINNEN FAMILY-SEBUD-PEELER (MT171)			6.45	0.9%	6.45	0.5%
TRIMAD-KALSTED-CRAGO (MT580)			3.99	0.5%	3.99	0.3%
LIBEG-MAURICE-CHEADLE (MT333)			3.28	0.4%	3.28	0.2%
NEEN-TRUDAU-RIVRA (MT413)			2.26	0.3%	2.26	0.2%
CRAGO-AMESHA-MUSSELSHELL (MT144)	1.98	0.3%			1.98	0.1%
RIVRA-HAGGA FAMILY-TRUDAU (MT481)			0.19	0.0%	0.19	0.0%
DINNEN FAMILY-LUCKY-CHEADLE (MT170)			0.00	0.0%	0.00	0.0%
Combined	602.36	100.0%	734.55	100.0%	1336.9	100.0%

ATTACHMENT E
MINERAL PROSPECTS AND OPERATIONS, JEFFERSON RIVER PLANNING AREAS

NAME	OPTYPE	STATUS	TWN	NS	RNG	EW	SECT	QUAD	COM
INGLESIDE QUARRY	Surface	Unknown	1	N	1	W	33	Three forks	Stone
UNNAMED LOCATION	Mineral loc	Unknown	3	S	6	E	22	Bozeman pass	Asbestos
UNNAMED LOCATION	Mineral loc	Unknown	2	S	6	E	4	Bozeman pass	Phosphate
GRAVEL PIT	Surface	Unknown	1	N	1	E	2	Three forks	Sand & gra
PLACER	Placer	Exp prospect	2	N	1	E	26	Three forks	Gold
SAPPINGTON JUNCTION CHERT	Prospect	Raw prospect	1	N	2	W	36	Jefferson island	
MONTANA TALC COMPANY	Proc plant	Past producer	1	N	1	W	32	Jefferson island	Talc
THREE FORKS MILL	Proc plant	Producer	1	N	1	E	25	Three forks	Talc
PIPESTONE HOT SPRINGS	Hot spring	Producer	2	N	5	W	28	Dry mountain	Geothermal
PROSPECTOR'S DREAM	Mineral loc	Exp prospect	1	N	2	W	18	Jefferson island	Asbestos
WAR EAGLE & LEROY MINES	Underground	Exp prospect	1	N	6	W	18	Pipestone pass	Copper iron
LA HOOD GYPSUM DEPOSIT	Surf-underg	Past producer	1	N	2	W	23	Jefferson island	Gypsum
INSPIRATION CLAIM	Underground	Past producer	2	N	3	W	19	Black butte	Copper lead gold silv
SURPRISE CLAIM	Underground	Past producer	2	N	3	W	18	Black butte	Lead silver gold zinc
PARROT	Surf-underg	Past producer	2	N	3	W	18	Black butte	Lead silver gold zinc co
SHIELDS-IRONSIDES	Surf-underg	Past producer	2	N	4	W	13	Black butte	Lead copper gold silver
SILVER BELL	Surf-underg	Past producer	3	N	5	W	3	Boulder	Lead
SOUTH VIEW	Underground	Past producer	2	N	4	W	24	Black butte	Silver gold lead zinc
WHITEHALL	Underground	Past producer	2	N	4	W	12	Black butte	Lead zinc silver
SUMMIT MINE	Underground	Past producer	4	N	5	W	16	Boulder	Lead
BLACKWELL	Underground	Past producer	3	N	7	W	36	Homestake	Gold
GOLDEN SUNLIGHT	Surface	Producer	2	N	3	W	19	Black butte;mt	Gold silver
LUCKY HIT	Underground	Past producer	2	N	3	W	19	Black butte	Gold lead silver copper
MOUNTAIN CHIEF	Underground	Past producer	3	N	7	W	36	Homestake	Gold
JUPITOR	Underground	Past producer	2	N	6	W	36	Delmoe lake	Gold
GOLD BUG	Underground	Past producer	2	N	6	W	6	Homestake	Gold
SUNNY CORNER	Underground	Past producer	2	N	4	W	24	Black butte	Gold silver copper
UNNAMED QUARTZ	Mineral loc	Unknown	4	N	5	W	10	Boulder	Quartz cry
BLUEBELL	Surface	Past producer	3	N	6	W	35	Delmoe lake	Lead silver zinc copper
CARBONATE	Underground	Past producer	2	N	4	W	24	Black butte	Lead zinc silver gold
MIDNIGHT	Underground	Past producer	2	N	3	W	18	Black butte	Lead silver gold copper
BIG MAJOR MINE	Underground	Producer	4	N	5	W	4	Boulder	Gold silver
EAST RIDGE GROUP	Surf-underg	Exp prospect	3	N	7	W	12	Elk park	Gold copper lead zinc
HUMBOLT	Underground	Producer	3	N	6	W	9	Elk park	Gold silver
MOUNTAIN QUEEN MINE	Underground	Past producer	4	N	5	W	27	Boulder	Copper silver lead uranium
NEW BALD EAGLE MINE	Surface	Past producer	4	N	5	W	16	Boulder	Gold silver
STREAK OF LUCK; SUNNYSIDE GROUP	Surf-underg	Producer	2	N	3	W	18	Black butte	Gold silver
SILVER QUEEN MINE	Underground	Past producer	2	N	5	W	6	Delmoe lake	Gold silver
BLACK CANYON PLACER	Placer	Producer	3	N	7	W	14	Elk park	Gold
MOSCOW MINE	Mineral loc	Past producer	1	N	6	W	16	Grace	Silver copper
FLAG PLACER	Placer	Past producer	2	N	7	W	1	Homestake	Gold

NAME	OPTYPE	STATUS	TWN	NS	RNG	EW	SECT	QUAD	COM
LEWIS KOUNTZ RANCH	Mineral loc	Raw prospect	1	N	5	W	8	Grace	Pumice
PIPESTONE SPRINGS DEPOSIT	Prospect	Raw prospect	2	N	5	W	14	Dry mountain	Pumice
HOPE	Mineral loc	Unknown	1	N	3	W	1	Jefferson island	Copper silver gold
BIG CHIEF	Underground	Devel deposit	3	N	6	W	28	Delmoe lake	Silver gold
SIXTEEN TO ONE	Surf-underg	Exp prospect	2	N	6	W	35	Delmoe lake	Gold
UNNAMED URANIUM	Mineral loc	Unknown	2	N	3	W	30	Black butte	Uranium
EXAMINER	Underground	Exp prospect	2	N	4	W	13	Black butte	Lead manganese
DUNBAR CALCITE	Mineral loc	Exp prospect	3	N	1	W	33	Three forks	Calcium
UNNAMED BRICK CLAY	Mineral loc	Raw prospect	2	N	4	W	25	Black butte	Clay
LIMESPUR DEPOSIT	Surface	Past producer	2	N	4	W	4	Black butte	Gypsum
LIMESPUR QUARRY	Surface	Past producer	1	N	2	W	19	Jefferson island	Stone
POHNDORF AMETHYST	Mineral loc	Past producer	1	N	6	W	4	Grace	Gemstone silicon
TREVILLION-JOHNSON MEMORIAL CO.	Surface	Past producer	1	N	6	W	15	Grace	Stone
DUMOS	Surface	Past producer	1	N	6	W	22	Grace	Stone
WELCH PLACER QUARRY	Surface	Past producer	2	N	6	W	10	Delmoe lake	Stone
BIG PIPESTONE CREEK	Placer	Devel deposit	2	N	5	W	19	Delmoe lake	Gold
LITTLE PIPESTONE CREEK PLACER	Placer	Devel deposit	1	N	5	W	8	Grace	Gold
BIGFOOT CREEK PLACE	Placer	Devel deposit	4	N	5	W	1	Boulder	Gold
AJAX	Underground	Unknown	4	N	5	W	14	Boulder	Lead copper zinc
UNNAMED LEAD & COPPER	Underground	Unknown	4	N	5	W	12	Boulder	Lead copper zinc
UNNAMED GYPSUM	Surface	Past producer	1	N	2	W	21	Jefferson island	Gypsum
UNNAMED QUARTZ	Mineral loc	Unknown	4	N	5	W	24	Boulder	Quartz cry
UNNAMED KAOLIN	Mineral loc	Unknown	1	N	2	W	26	Jefferson island	Clay
UNNAMED SILVER & COPPER	Mineral loc	Unknown	3	N	6	W	13	Elk park	Silver copper
UNNAMED GOLD & SILVER	Mineral loc	Unknown	3	N	5	W	16	Boulder	Gold silver copper zinc lead
BI-METALLIC	Underground	Producer	3	N	5	W	15	Boulder	Gold silver lead copper zinc
BIG FOUR	Underground	Past producer	4	N	5	W	12	Boulder	Lead zinc silver gold copper
BIG FOOT	Mineral loc	Unknown	4	N	5	W	15	Boulder	Lead gold silver
BIG FOOT CREEK	Placer	Unknown	4	N	4	W	7	Boulder	Gold
BLUE JAY	Underground	Unknown	4	N	5	W	15	Boulder	Lead zinc copper silver gold
EASTER LILLIE	Underground	Past producer	2	N	5	W	9	Dry mountain	Lead silver gold copper z
EVENING STAR	Mineral loc	Unknown	3	N	7	W	36	Homestake	Silver gold
FLORENCE GROUP	Underground	Devel deposit	2	N	3	W	18	Black butte	Gold silver
GEM MINE	Underground	Unknown	2	N	4	W	13	Black butte	Lead zinc silver copper gold
GLOWING STAR PLACER	Placer	Unknown	2	N	6	W	6	Homestake	Gold
HARRIET MINE	Underground	Unknown	2	N	7	W	1	Homestake	Gold silver
HOMESTAKE CREEK & TRIBUTARIES	Mineral loc	Unknown	2	N	6	W	7	Homestake	Gold silver
HUDSON	Underground	Raw prospect	2	N	3	W	18	Black butte	Lead

NAME	OPTYPE	STATUS	TWN	NS	RNG	EW	SECT	QUAD	COM
JACK MINE	Mineral loc	Unknown	4	N	5	W	27	Boulder	Lead uranium
JIM JR. CLAIM	Mineral loc	Unknown	3	N	6	W	16	Elk park	Gold silver copper
LAST CHANCE	Underground	Unknown	4	N	5	W	15	Boulder	Gold silver copper
LENA MINE	Underground	Unknown	2	N	6	W	15	Delmoe lake	Gold lead
LOST CABIN MINE	Underground	Unknown	4	N	5	W	15	Boulder	Lead gold silver copper
MINERVA MINE	Underground	Unknown	2	N	4	W	13	Black butte	Lead gold silver zinc copper
MONTANA MINE	Underground	Exp prospect	2	N	6	W	6	Homestake	Gold silver
MORNING GLORY	Mineral loc	Unknown	2	N	6	W	6	Homestake	Gold
NANNIE BROWN MINE	Mineral loc	Unknown	3	N	7	W	36	Homestake	Gold silver
NIKI MINE	Mineral loc	Unknown	3	N	6	W	18	Elk park	Molybdenum tungsten
PAY ROCK MINE	Underground	Unknown	2	N	6	W	6	Homestake	Gold silver copper gold
PERHAPS MINE	Underground	Unknown	2	N	3	W	18	Black butte	Lead zinc gold copper silver
STATE MINE	Underground	Past producer	4	N	5	W	16	Boulder	Gold silver copper lead
ST. ANTHONY MINE	Underground	Past producer	3	N	5	W	3	Boulder	Gold silver lead
TOLL MOUNTAIN	Mineral loc	Unknown	1	N	6	W	5	Pipestone pass	Quartz cry
WOODVILLE DEPOSIT	Mineral loc	Unknown	3	N	6	W	6	Elk park	Tungsten
UNNAMED MINE	Underground	Past producer	3	N	6	W	18	Elk park	Gold silver lead
KING MINE	Underground	Past producer	3	N	5	W	30	Delmoe lake	
NORTH SUNLIGHT GROUP	Underground	Devel deposit	2	N	3	W	19	Black butte	Gold silver copper lead
LUCKY KAREN PLACER	Placer	Past producer	3	N	7	W	16	Elk park	Gold
BUTTE TUNGSTEN	Surf-underg	Devel deposit	3	N	6	W	17	Elk park	Tungsten
TWOHY PROPERTY	Mineral loc	Exp prospect	3	N	5	W	3	Boulder	Lead zinc
OGLE PROPERTY	Underground	Past producer	2	N	4	W	16	Black butte	Lead manganese
MINNIE WILSON	Surf-underg	Exp prospect	2	N	5	W	9	Dry mountain	Gold silver
NEW DEAL	Underground	Unknown	2	N	5	W	4	Dry mountain	Gold silver
GOLDEN VALLEY	Underground	Unknown	2	N	5	W	4	Dry mountain	Gold silver copper lead
LOST HATCHET	Underground	Unknown	2	N	5	W	4	Dry mountain	Gold silver copper
BLUE MOOSE	Mineral loc	Unknown	2	N	3	W	29	Black butte	Gold
TOWNSEND VALLEY	Mineral loc	Unknown	2	N	1	W	11	Three forks	Uranium
BUTTE CARDWELL	Underground	Past producer	1	N	3	W	1	Jefferson island	Copper silver gold
CONNIE JO	Underground	Past producer	2	N	6	W	1	Delmoe lake	Gold silver
GOLD VALLEY	Underground	Past producer	1	N	5	W	19	Grace	Gold
GOLD STAR	Underground	Past producer	2	N	4	W	25	Black butte	Lead gold silver copper
IRENE	Underground	Past producer	3	N	7	W	36	Homestake	Gold silver copper
MARY LUCILLE	Underground	Past producer	2	N	3	W	9	Black butte	Lead gold
OHIO	Underground	Past producer	2	N	3	W	19	Black butte	Gold silver copper
SAPPINGTON CANYON	Unknown	Unknown	1	N	2	W	25	Jefferson island	Phosphate

NAME	OPTYPE	STATUS	TWN	NS	RNG	EW	SECT	QUAD	COM
THREE FORKS	Unknown	Unknown	2	N	1	W	24	Three forks	Silver
PAY DAY GROUP	Surf-underg	Producer	2	N	3	W	18	Black butte	Gold silver
ALUISE LODE	Unknown	Unknown	3	N	6	W	35	Delmoe lake	Gold
BLUE ROCK LODE	Unknown	Unknown	3	N	6	W	26	Delmoe lake	Gold silver
19 MILE NICKEL DEPOSIT	Unknown	Unknown	1	N	6	W	16	Grace	Nickel
IRON KING CLAIM	Underground	Past producer	1	S	4	W	5	Whitehall	Manganese
IRON BLOSSOM NO 1 CLAIM	Surface	Unknown	1	S	4	W	3	Whitehall	Manganese
IRON BLOSSOM NUMBER 3	Surface	Unknown	1	S	4	W	3	Whitehall	Iron manganese
JACKMAN-OGLE	Underground	Exp prospect	1	S	4	W	5	Whitehall	Manganese
BARKEL'S HOT SPRINGS	Hot spring	Producer	2	S	6	W	1	Twin bridges	Geothermal
CLARK'S WARM SPRINGS	Hot spring	Raw prospect	3	S	2	W	7	Harrison	Geothermal
FLORIDA GIANT	Underground	Devel deposit	3	S	4	W	6	Waterloo	Gold silver
GREEN CAMPBELL	Underground	Past producer	2	S	6	W	3	Twin bridges	Gold copper
SAILOR LAKE MINE	Mineral loc	Exp prospect	2	S	4	W	35	Waterloo	Copper lead molybdenum
BESSIE AND GOLDEN WAVE MINE	Underground	Producer	2	S	2	W	14	Harrison	Gold silver copper tungsten
MOFFET JOHNSON	Surf-underg	Past producer	3	S	5	W	2	Waterloo	Copper gold silver
MAYFLOWER	Underground	Past producer	1	N	3	W	32	White hall	Gold silver tellurium
MAMMOTH AND STELLA MINES	Underground	Past producer	2	S	6	W	9	Twin bridges	Copper silver lead
ATLANTIC & PACIFIC MINE	Underground	Past producer	2	S	3	W	20	Harrison	Gold silver copper
GRANITE PEAK	Surface	Raw prospect	3	S	3	W	30	Waterloo	Molybdenum tungsten
CARMICHAEL CLAIMS	Surface	Exp prospect	1	S	3	W	34	Harrison	Iron
RASPBERRY MINE	Underground	Past producer	2	S	3	W	14	Harrison	Lead gold
TEXAS LODE MINE	Surf-underg	Past producer	3	S	5	W	26	Waterloo	Lead gold silver zinc
BLUE ROCK AND MAY BASKET	Surf-underg	Exp prospect	2	S	2	W	33	Harrison	Lead molybdenum silver
RAINBOW	Underground	Past producer	3	S	4	W	5	Waterloo	Lead zinc silver gold
SUNBEAM	Underground	Devel deposit	1	S	4	W	5	Whitehall	Manganese
QUARTZ CITY MINE	Underground	Exp prospect	2	S	4	W	35	Waterloo	Molybdenum
GRIGG GROUP	Surf-underg	Exp prospect	3	S	3	W	16	Harrison	Molybdenum lead tungsten
PRESIDENTIAL GROUP	Surf-underg	Devel deposit	3	S	3	W	16	Harrison	Tungsten
CRYSTAL BUTTE	Mineral loc	Raw prospect	3	S	4	W	4	Waterloo	Silicon
PERRY CANYON	Surf-underg	Exp prospect	1	S	4	W	17	Vendome	Tungsten
STRAWBERRY MINE	Surface	Past producer	2	S	3	W	14	Harrison	Tungsten gold silver copper
NOW PROPERTY	Underground	Exp prospect	3	S	2	W	2	Harrison	Tungsten manganese uranium
NORTH WILLOW CREEK TUNGSTEN DEPOSIT	Underground	Past producer	2	S	3	W	24	Harrison	Tungsten molybdenum
NEVADA GROUP CLAIMS	Surf-underg	Exp prospect	3	S	3	W	15	Harrison	Tungsten
MOUNTAIN ROSE CLAIM	Underground	Exp prospect	3	S	3	W	15	Harrison	Tungsten

NAME	OPTYPE	STATUS	TWN	NS	RNG	EW	SECT	QUAD	COM
STASNOS	Underground	Exp prospect	3	S	3	W	15	Harrison	Tungsten
WILLIAM FLY	Surf-underg	Exp prospect	3	S	3	W	22	Harrison	Tungsten lead
GREEN JACKET	Surf-underg	Exp prospect	3	S	3	W	16	Harrison	Tungsten copper
CROWN POINT CLAIMS	Underground	Exp prospect	3	S	3	W	17	Harrison	Tungsten copper silver
DEMOS GROUP	Surf-underg	Exp prospect	3	S	3	W	16	Harrison	Tungsten copper manganese lead
KEYSTONE CLAIM	Surface	Exp prospect	3	S	3	W	15	Harrison	Tungsten copper
U.S. GOLD CORP.	Underground	Past producer	3	S	4	W	8	Waterloo	Copper gold lead silver
PETE AND JOE	Underground	Producer	3	S	4	W	8	Waterloo	Gold silver copper lead
BEVERLY GROUP	Surface	Past producer	2	S	6	W	8	Twin bridges	Gold silver
DIVIDEND LODE MINE	Underground	Exp prospect	2	S	3	W	15	Harrison	Gold silver
FRIDA MARIE CLAIM	Underground	Past producer	2	S	6	W	10	Twin bridges	Silver gold
JUMPER CLAIMS	Underground	Past producer	2	S	3	W	27	Harrison	Gold silver copper
SCALDED CAT MINE	Underground	Exp prospect	2	S	3	W	14	Harrison	Gold silver copper tungsten
VICTORIA MINE	Underground	Past producer	2	S	6	W	2	Twin bridges	Gold silver lead copper
IRON ROD	Underground	Past producer	2	S	6	W	22	Twin bridges	Gold lead
UNNAMED MINE	Surface	Unknown	2	S	1	W	12	Norris	
BUFFALO	Underground	Unknown	2	S	7	W	33	Twin bridges	Gold
BROADWAY	Underground	Past producer	2	S	6	W	2	Twin bridges	Gold silver
HIGH RIDGE	Underground	Past producer	3	S	5	W	27	Waterloo	Gold silver
AURORA	Underground	Past producer	2	S	6	W	3	Twin bridges	Gold lead silver
ANYTHING MINE	Underground	Past producer	2	S	7	W	33	Twin bridges	Gold copper lead
BOULDER-COBALT MINE	Underground	Past producer	3	S	4	W	5	Waterloo	Gold silver copper lead c
WHITE PINE	Underground	Past producer	2	S	3	W	9	Harrison	Gold silver copper zinc
HAZEL MINE	Underground	Exp prospect	3	S	3	W	22	Harrison	Silver
BLUE JAY GROUP	Prospect	Exp prospect	2	S	6	W	10	Twin bridges	Copper
LUCKY SILVER	Unknown	Producer	3	S	5	W	16	Waterloo	Silver
SILVER CREEK MINE	Underground	Past producer	2	S	3	W	32	Harrison	
TIDAL WAVE	Underground	Past producer	3	S	5	W	28	Waterloo	Gold silver lead zinc
RICHMOND GROUP	Underground	Past producer	3	S	5	W	22	Waterloo	Gold silver copper zinc lead
UNNAMED GRAVEL PIT	Surface	Unknown	3	S	6	W	11	Twin bridges	Sand & gra
UNNAMED GRAVEL PIT	Surface	Unknown	3	S	6	W	26	Twin bridges	Sand & gra
HAMILTON	Underground	Exp prospect	3	S	5	W	1	Waterloo	Gold copper manganese
UNNAMED GRAVEL PIT	Surface	Unknown	3	S	6	W	35	Twin bridges	Sand & gra
CRYSTAL LAKE	Underground	Past producer	3	S	5	W	26	Waterloo	Gold
ELENORA	Underground	Past producer	3	S	5	W	26	Waterloo	Gold silver lead
CAROLINA MINE	Underground	Past producer	3	S	5	W	23	Waterloo	Gold silver zinc lead copper
LOTTIE MINE	Underground	Past producer	3	S	5	W	23	Waterloo	Gold silver zinc
CORNCRACKER MINE	Underground	Past producer	3	S	5	W	34	Waterloo	Gold silver lead

NAME	OPTYPE	STATUS	TWN	NS	RNG	EW	SECT	QUAD	COM
BRYZANT MINE	Surf-underg	Past producer	3	S	5	W	33	Waterloo	Lead zinc silver
SUNFLOWER 1	Underground	Exp prospect	3	S	5	W	27	Waterloo	Gold silver lead zinc
UNNAMED GRAVEL PIT	Surface	Unknown	4	S	6	W	12	Twin bridges	Sand & gra
MAINSTREET	Underground	Exp prospect	3	S	5	W	26	Waterloo	Gold copper iron
COP PROSPECT	Underground	Past producer	3	S	5	W	27	Waterloo	Gold zinc
ELLA MINE	Underground	Past producer	3	S	5	W	26	Waterloo	Gold silver lead
LONE STAR PROSPECT	Underground	Exp prospect	3	S	5	W	26	Waterloo	Gold silver zinc copper
UNNAMED MINE	Underground	Unknown	3	S	7	W	12	Twin bridges	
DULLEA ADIT 1	Underground	Exp prospect	3	S	5	W	26	Waterloo	Gold silver lead copper zinc
UNNAMED MINE	Surface	Unknown	3	S	6	W	2	Twin bridges	
UNNAMED PROSPECTS	Mineral loc	Unknown	2	S	6	W	15	Twin bridges	
ARGENTA ADIT 1	Underground	Exp prospect	3	S	5	W	26	Waterloo	Lead gold
UNNAMED PROSPECTS	Mineral loc	Unknown	2	S	6	W	15	Twin bridges	
UNNAMED PROSPECTS	Mineral loc	Unknown	2	S	6	W	9	Twin bridges	
KRUEGER NORTH ADIT	Underground	Exp prospect	3	S	5	W	16	Waterloo	Gold silver copper lead zi
JULIA LEE MINE	Underground	Unknown	2	S	6	W	7	Twin bridges	Silver gold
CRICKET MINE	Underground	Past producer	2	S	6	W	10	Twin bridges	
BEAR GULCH ADIT	Underground	Past producer	3	S	5	W	10	Waterloo	Gold silver copper iron zinc
UNNAMED SURFACE PIT	Surface	Exp prospect	3	S	5	W	10	Waterloo	Gold silver zinc copper
BISMUTH PROSPECT	Underground	Exp prospect	3	S	5	W	22	Waterloo	Gold silver zinc copper iron
UNNAMED PROSPECT	Underground	Exp prospect	3	S	5	W	33	Waterloo	Gold
NEW YORK PROSPECT	Underground	Exp prospect	3	S	5	W	27	Waterloo	Gold silver
FORK PROSPECT	Underground	Devel deposit	3	S	5	W	34	Waterloo	Silver lead
PEARSON PROSPECT	Underground	Exp prospect	3	S	5	W	34	Waterloo	Gold silver lead copper
BULLIDICK PROSPECT	Underground	Exp prospect	3	S	5	W	27	Waterloo	Gold silver copper zinc ir
UNNAMED PROSPECTS	Mineral loc	Unknown	2	S	6	W	9	Twin bridges	
BISMARK-NUGGET ADITS	Underground	Past producer	3	S	5	W	26	Waterloo	Gold silver lead copper
URHANE	Underground	Past producer	3	S	5	W	22	Waterloo	Gold silver
SCHMIDT PROSPECTS NORTH	Surf-underg	Exp prospect	3	S	5	W	24	Waterloo	Zinc
RED BELL	Underground	Exp prospect	3	S	5	W	24	Waterloo	Gold silver
EMPIRE STATE	Underground	Exp prospect	3	S	5	W	27	Waterloo	Gold silver copper lead zinc
PLAINVIEW	Underground	Exp prospect	3	S	5	W	28	Waterloo	Gold silver
WALKER MINE	Underground	Past producer	3	S	5	W	34	Waterloo	Gold silver
CLANCY MINE	Surface	Unknown	1	S	6	W	33	Twin bridges	Gold silver copper
COLORADO MINE	Underground	Past producer	1	S	4	W	3	Whitehall	Gold silver
UNNAMED PROSPECTS	Mineral loc	Unknown	2	S	6	W	4	Twin bridges	
LEODORA	Underground	Exp prospect	3	S	5	W	4	Waterloo	Gold silver lead
STRAWW MINE	Underground	Past producer	2	S	4	W	18	Waterloo	Gold silver antimony

NAME	OPTYPE	STATUS	TWN	NS	RNG	EW	SECT	QUAD	COM
UNNAMED PROSPECTS	Mineral loc	Unknown	2	S	6	W	4	Twin bridges	
NICHOLSON MINE	Underground	Past producer	3	S	3	W	7	Waterloo	Gold silver
BISMARK MINE	Underground	Past producer	2	S	4	W	36	Waterloo	Molybdenum iron copper
SNYDER'S MINE	Underground	Past producer	3	S	4	W	4	Waterloo	
GARNET GOLD MINE	Underground	Past producer	2	S	3	W	23	Harrison	Gold silver lead copper
BOSS TWEED AND CLIPPER	Underground	Past producer	2	S	3	W	15	Harrison	Gold silver copper
KEYSTONE	Underground	Past producer	2	S	6	W	3	Twin bridges	Gold silver tungsten
MONTANA 1 MINE	Underground	Exp prospect	1	S	4	W	5	Whitehall	Iron
IRON OCCURRENCE	Mineral loc	Raw prospect	1	N	4	W	32	Whitehall	Iron
BEAR GULCH PLACER	Placer	Past producer	3	S	5	W	11	Waterloo	Gold
GOODRICH GULCH PLACER	Placer	Past producer	3	S	5	W	24	Waterloo	Gold
DRY GEORGIA GULCH	Placer	Past producer	3	S	5	W	26	Waterloo	Gold
RED MOUNTAIN PLACER	Placer	Past producer	1	S	7	W	34	Twin bridges	Gold
SILVER STAR PLACER	Placer	Past producer	2	S	6	W	20	Twin bridges	Gold
FIRST CREEK PLACER	Placer	Raw prospect	2	S	6	W	17	Twin bridges	Gold
DAIZY NO. 1	Mineral loc	Unknown	3	S	4	W	15	Waterloo	Gold silver lead
SOUTH BOULDER RIVER PLACER	Placer	Past producer	2	S	3	W	6	Waterloo	Gold
JEFFERSON RIVER PLACERS	Placer	Past producer	1	N	3	W	13	Jefferson island	Gold
BIG ANTELOPE CREEK - NORTH PLACERS	Placer	Past producer	1	N	2	W	35	Jefferson island	Gold
BIG ANTELOPE CREEK- SOUTH PLACERS	Placer	Past producer	1	S	3	W	36	Harrison	Gold
PONY CREEK PLACER	Placer	Past producer	2	S	3	W	13	Harrison	Gold
NORWEGIAN CREEK	Placer	Past producer	2	S	2	W	36	Harrison	Gold
BEN HARRISON FRACTURE	Underground	Past producer	2	S	3	W	21	Harrison	Gold silver
LONE WOLF AND CATARACT	Underground	Past producer	2	S	3	W	16	Harrison	Gold silver
BOZEMAN MINE	Underground	Past producer	2	S	3	W	15	Harrison	Gold silver
NORWEGIAN	Underground	Past producer	3	S	2	W	1	Harrison	Gold silver
SILVER STAR CHROMITE	Surf-underg	Past producer	2	S	6	W	10	Twin bridges	Chromium
LEAD QUEEN	Underground	Unknown	3	S	5	W	15	Waterloo	Gold silver iron
SURPRISE MINE	Surf-underg	Past producer	1	N	3	W	25	Jefferson island	Gold silver
CHILE	Underground	Past producer	1	S	1	W	18	Jefferson island	Gold
WHIPPOORWILL	Underground	Past producer	1	S	1	W	18	Jefferson island	Gold
OLD JOE	Underground	Past producer	2	S	3	W	23	Harrison	Gold
WILLOW CREEK CLAIM	Underground	Past producer	2	S	3	W	15	Harrison	Gold
NED	Underground	Past producer	2	S	3	W	14	Harrison	Gold
MOUNTAIN CLIFF	Underground	Past producer	2	S	3	W	15	Harrison	Gold silver lead

NAME	OPTYPE	STATUS	TWN	NS	RNG	EW	SECT	QUAD	COM
COPPER QUEEN	Underground	Past producer	2	S	5	W	35	Waterloo	Copper
DEMOCRAT	Underground	Past producer	3	S	5	W	26	Waterloo	Gold silver
TOPEKA	Underground	Past producer	3	S	5	W	24	Waterloo	Gold silver
LITTLE GOLDIE	Underground	Past producer	3	S	5	W	24	Waterloo	Gold silver
NETTIE	Underground	Past producer	3	S	5	W	24	Waterloo	Gold silver
MOGULLIAN	Underground	Past producer	3	S	4	W	1	Waterloo	Silver
UNNAMED DEPOSIT	Mineral loc	Unknown	3	S	5	W	34	Waterloo	Gold silver copper lead zinc
UNNAMED RARE EARTH DEPOSIT	Mineral loc	Unknown	1	S	2	W	1	Jefferson island	Rare earth
UNNAMED DEPOSIT	Mineral loc	Unknown	3	S	5	W	10	Waterloo	Gold silver copper zinc lead
UNNAMED DEPOSIT	Mineral loc	Unknown	3	S	5	W	33	Waterloo	Gold silver lead copper zinc
IRON OCCURRENCE	Mineral loc	Unknown	2	S	2	W	6	Harrison	Iron
UNNAMED RARE EARTH DEPOSIT	Mineral loc	Unknown	2	S	1	W	22	Norris	Rare earth thorium
UNNAMED PHOSPHORUS DEPOSIT	Mineral loc	Unknown	1	S	4	W	1	Whitehall	Phosphate
UNNAMED DEPOSIT	Mineral loc	Unknown	1	S	3	W	35	Harrison	Feldspar mica asbestos kyanite gr talc
UNNAMED DEPOSIT	Mineral loc	Unknown	1	S	3	W	25	Harrison	Feldspar mica asbestos kyanite gr talc
ANTELOPE CHROMITE DEPOSIT	Mineral loc	Unknown	1	S	3	W	35	Harrison	Chromium
BACCHARAT MINE	Underground	Unknown	2	S	6	W	15	Twin bridges	Gold iron copper
MINERAL HILL	Underground	Past producer	1	S	3	W	26	Harrison	Talc
BLUE GROUSE MINE	Underground	Unknown	1	S	4	W	4	Whitehall	Gold silver lead copper
BROWN MINE	Underground	Unknown	2	S	6	W	16	Twin bridges	Gold silver zinc
CLIPPER MINE	Underground	Past producer	2	S	6	W	15	Twin bridges	Gold lead copper
DRY BOULDER IRON	Underground	Raw prospect	3	S	4	W	5	Waterloo	Iron titanium
EDGERTON MINE	Underground	Unknown	2	S	6	W	3	Twin bridges	Gold
EMMA B GROUP	Underground	Exp prospect	3	S	4	W	13	Waterloo	Gold silver
GALENA MINE	Underground	Past producer	2	S	6	W	3	Twin bridges	Gold lead copper
GERMANIA	Mineral loc	Unknown	3	S	7	W	3	Twin bridges	Gold silver
GILLIAM MINE	Underground	Unknown	1	S	3	W	26	Harrison	Vermiculit
GOLDEN ROD	Underground	Unknown	2	S	6	W	1	Twin bridges	Gold lead copper
GOLDEN LINK	Underground	Unknown	3	S	2	W	1	Harrison	Gold silver
KING SHAFT	Mineral loc	Unknown	2	S	6	W	33	Twin bridges	Gold silver
LEAD ORE MINE	Underground	Exp prospect	3	S	3	W	23	Harrison	Gold silver lead
LITTLE BEAR PROPERTIES	Mineral loc	Unknown	3	S	5	W	12	Waterloo	Lead silver
MACMASTERS MINE	Underground	Unknown	1	S	4	W	3	Whitehall	Gold silver
MADISON C	Mineral loc	Unknown	2	S	1	W	28	Norris	Quartz cry
MAMMOTH	Underground	Past producer	2	S	3	W	18	Waterloo	Gold silver copper
MARY INGABER MINE	Underground	Unknown	1	S	4	W	4	Whitehall	Gold silver copper
MOHAWK MINE	Underground	Unknown	2	S	6	W	10	Twin bridges	Chromium
MONTANA NO 1 MINE	Underground	Raw prospect	1	S	4	W	5	Whitehall	Iron

NAME	OPTYPE	STATUS	TWN	NS	RNG	EW	SECT	QUAD	COM
NORWEGIAN GULCH DEPOSIT	Mineral loc	Unknown	2	S	2	W	36	Harrison	Kyanite gr
POLLINGER MINE	Underground	Unknown	2	S	6	W	2	Twin bridges	Gold silver
ARIZONA	Underground	Past producer	2	S	3	W	34	Harrison	Gold silver copper
RANGER MINE	Underground	Unknown	3	S	5	W	22	Waterlay	Gold silver lead
RED CHIEF	Underground	Unknown	3	S	2	W	1	Norris	Gold silver
RHYOLITE MINE	Underground	Unknown	2	S	6	W	3	Twin bridges	Lead silver
RIDGEWAY MINE	Underground	Exp prospect	2	S	3	W	10	Harrison	Gold silver
RIVERSIDE MINE	Underground	Exp prospect	2	S	3	W	22	Harrison	Gold silver
SAPPINGTON MICA MINE	Surface	Unknown	1	S	1	W	9	Three forks	Mica
SHAMROCK MINE	Underground	Past producer	1	S	6	W	33	Twin bridges	Copper silver gold
SILICA BUTTE	Unknown	Unknown	2	S	7	W	1	Twin bridges	Quartz cry
SUNLIGHT MINE	Underground	Unknown	3	S	4	W	23	Waterloo	Gold
VIKING MINE	Underground	Past producer	2	S	3	W	21	Harrison	Gold
WHIP-POOR-WILL GROUP	Underground	Past producer	2	S	3	W	14	Harrison	Gold
WHITE ANGEL QUARRY	Surface	Unknown	3	S	5	W	27	Waterloo	Calcium
WILSON MINE	Underground	Unknown	3	S	4	W	19	Waterloo	Gold silver
SAPPINGTON BERRYLIUM DEPOSIT	Mineral loc	Unknown	1	S	1	W	9	Three forks	Beryllium
BONANZA FRACTION	Underground	Past producer	1	N	4	W	34	Whitehall	Gold silver copper lead
JEFFERSON CANYON PHOSPHORIA	Mineral loc	Exp prospect	1	N	3	W	13	Jefferson island	Phosphate
SOUTH BOULDER CREEK	Mineral loc	Exp prospect	1	S	3	W	10	Jefferson island	Phosphate
AMERICAN PIT	Underground	Past producer	2	S	6	W	22	Twin bridges	Gold silver copper
CLIFFORD MINE	Underground	Past producer	2	S	6	W	9	Twin bridges	Gold silver lead copper
MOONLIGHT-WHITE ELEPHANT	Mineral loc	Past producer	2	S	6	W	16	Twin bridges	Gold
OHIO QUARTZ	Mineral loc	Past producer	2	S	6	W	16	Twin bridges	Gold
SAPPINGTON LIMESTONE DEPOSIT	Mineral loc	Raw prospect	1	N	2	W	35	Harrison	Stone
PONY VERMICULITE	Mineral loc	Unknown	1	S	3	W	25	Harrison	Vermiculit
MOUNTAIN MEADOW	Underground	Exp prospect	2	S	3	W	21	Harrison	
MEADOWLARK	Surface	Exp prospect	1	S	4	W	4	Whitehalle	Gold silver copper
UNNAMED MINE	Underground	Unknown	1	N	4	W	34	Whitehall	
UNNAMED MINE	Underground	Unknown	1	N	4	W	34	Whitehall	
UNNAMED MINE	Underground	Unknown	1	N	4	W	34	Whitehall	
LITTLE NUGGET	Underground	Unknown	1	S	4	W	4	Whitehall	Gold silver
UNNAMED MINE	Underground	Unknown	1	S	4	W	4	Whitehall	
UNNAMED MINE	Underground	Unknown	1	S	4	W	4	Whitehall	
UNNAMED ADIT CLUSTER	Underground	Unknown	1	S	4	W	4	Whitehall	
UNNAMED MINES	Underground	Unknown	1	S	4	W	4	Whitehall	
UNNAMED MINES	Underground	Unknown	1	S	4	W	4	Whitehall	

NAME	OPTYPE	STATUS	TWN	NS	RNG	EW	SECT	QUAD	COM
UNNAMED MINES	Underground	Unknown	1	S	4	W	10	Whitehall	
UNNAMED MINES	Underground	Unknown	1	N	4	W	34	Whitehall	
UNNAMED MINE	Underground	Unknown	1	S	4	W	22	Waterloo	
UNNAMED GRAVEL PIT	Surface	Unknown	2	S	4	W	6	Waterloo	Sand & gra
OHIO LODE MINE	Underground	Unknown	2	S	5	W	25	Waterloo	
GIANT MINE	Mineral loc	Unknown	3	S	5	W	12	Waterloo	Gold
GROUSE MINE	Underground	Past producer	3	S	5	W	13	Waterloo	Gold
UNNAMED MINE	Underground	Unknown	3	S	5	W	23	Waterloo	
UNNAMED MINE	Underground	Unknown	3	S	5	W	23	Waterloo	
UNNAMED ADIT CLUSTER	Underground	Unknown	3	S	4	W	7	Waterloo	
UNNAMED MINE	Underground	Unknown	3	S	5	W	1	Waterloo	
HUDSON MINE	Mineral loc	Unknown	2	S	6	W	2	Twin bridges	Gold silver lead zinc
HARRISON IRON	Surface	Raw prospect	1	S	2	W	34	Harrison	Iron
PONY IRON DEPOSIT	Surface	Raw prospect	2	S	2	W	6	Waterloo	Iron
OREGON	Underground	Exp prospect	2	S	3	W	15	Harrison	Gold
LAKEVIEW	Underground	Unknown	3	S	4	W	3	Waterloo	Gold silver copper lead zinc
INSPIRATION GOLD	Underground	Unknown	3	S	5	W	12	Waterloo	Gold silver
ISABELLE	Underground	Unknown	3	S	5	W	12	Waterloo	Gold silver
MAMMOTH-BUTTE	Underground	Unknown	2	S	5	W	4	Waterloo	Gold silver
BAYARD	Underground	Past producer	2	S	4	W	19	Waterloo	Silver copper lead zinc
DUTCHLAND	Underground	Past producer	3	S	5	W	28	Waterloo	Lead silver copper
EDMOND FOREST	Underground	Past producer	2	S	5	W	16	Waterloo	Gold silver copper
KLONDIKE	Underground	Past producer	3	S	4	W	10	Waterloo	Gold silver
BI-METALIC	Underground	Past producer	3	S	2	W	12	Harrison	Gold silver
FLORENCE	Underground	Devel deposit	1	S	4	W	9	Whitehall	Iron
UNNAMED MICA	Unknown	Unknown	1	S	1	E	9	Three forks	Mica
RY & K MINE	Surface	Exp prospect	3	S	2	W	2	Harrison	Gold silver
ANTLER MINE	Surface	Producer	2	S	6	W	14	Twin bridges	Talc
CONSTELLATION DEPOSIT	Surface	Producer	1	S	3	W	26	Harrison	Vermiculit
ANTELOPE-PONY	Underground	Raw prospect	2	S	3	W	10	Harrison	Platinum g platinum g platinum g
NEVER SWEAT	Underground	Past producer	2	S	3	W	13	Harrison	Silver
NORWEIGEN	Placer	Past producer	2	S	2	W	13	Harrison mont.	Iron
MOUNTAIN VIEW MINE	Underground	Devel deposit	3	S	5	W	2		Gold silver copper lead
SPUHLER GROUP	Underground	Devel deposit	3	S	4	W	20	Waterloo	Gold silver lead
VANGUARD GROUP	Underground	Exp prospect	4	S	3	W	5	Harrison	Gold silver
MOOSE CREEK-FISH CREEK TRAVERSE	Mineral loc	Unknown	1	N	7	W	32	Pipestone pass	Gold silver c
EDNA KIBLER PROSPECT	Surface	Unknown	1	N	6	W	20	Pipestone pass	Iron

NAME	OPTYPE	STATUS	TWN	NS	RNG	EW	SECT	QUAD	COM
DENNY PROSPECT	Underground	Unknown	1	N	7	W	22	Pipestone pass	Tungsten molybdenum
SILVER KING PLACER	Placer	Producer	1	N	7	W	28	Pipestone pass	Gold
MCPHAIL PROSPECT	Underground	Unknown	1	N	7	W	32	Pipestone pass	Gold
OVERLOOK GROUP MINE	Surf-underg	Producer	1	N	7	W	22	Pipestone pass	Gold silver copper
HIGHLANDS MINE	Underground	Past producer	1	N	7	W	31	Butte south	Gold
BALLARAT	Underground	Past producer	1	N	7	W	33	Pipestone pass	Gold
TEMPLEMAN	Underground	Unknown	1	N	7	W	33	Butte north	Gold silver lead zinc
OZARK	Underground	Past producer	1	N	7	W	33	Pipestone pass	Gold
BROOKS	Underground	Past producer	1	N	7	W	29	Pipestone pass	Gold
RED WING	Underground	Past producer	1	N	7	W	28	Pipestone pass	Gold
IRON CLIFF	Underground	Unknown	1	N	7	W	22	Pipestone pass	Gold
HIGHLAND VIEW	Surf-underg	Unknown	1	N	7	W	28	Pipestone pass	Gold
BEAR CAT	Underground	Unknown	1	N	7	W	27	Pipestone pass	Silver copper
READYCASH	Underground	Past producer	1	N	7	W	22	Pipestone pass	Gold copper
EXL	Underground	Past producer	1	N	7	W	35	Pipestone pass	Gold
FISH CREEK MINE	Surf-underg	Past producer	1	N	7	W	31	Butte south	Silver copper
LIMESTONE OCCURRENCE	Mineral loc	Unknown	1	N	7	W	22	Pipestone pass	Abrasive stone
GRACE	Mineral loc	Unknown	1	S	6	W	11	Grace	Silicon
LITTLE JOE-HAZEL CLAIM	Underground	Unknown	1	N	7	W	16	Pipestone pass	Gold silver
HIGHLAND PLACER	Placer	Past producer	1	N	7	W	32	Pipestone pass	Gold
FISH CREEK PLACERS	Placer	Producer	1	N	7	W	28	Pipestone pass	Gold
GLORIA ALICE PLACER	Placer	Past producer	1	N	7	W	2	Pipestone pass	Gold
LAST CHANCE MINE	Underground	Devel deposit	1	N	7	W	28	Pipestone pass	Gold silver
MOONLIGHT MINE	Underground	Devel deposit	1	N	7	W	28	Pipestone pass	Silver gold
STRATTON MINE	Underground	Producer	1	N	7	W	32	Pipestone pass	Gold silver copper
B & N PORTABLE CRUSHER	Surface	Past producer	36	N	1	E	17		Sand & gra
HERBERT DUNBAR	Underground	Devel deposit	3	N	1	E	28	Three forks	Iron
COPPER CITY	Surf-underg	Devel deposit	3	N	1	E	25	Three forks	Copper iron

APPENDIX B
REGULATORY FRAMEWORK AND REFERENCE CONDITION APPROACH

This appendix presents details about applicable Montana Water Quality Standards (WQS) and the general and statistical methods used for development of reference conditions.

1.0 TMDL Development Requirements

Section 303 of the Federal CWA and the Montana WQA (Section 75-5-703) requires development of TMDLs for impaired water bodies that do not meet Montana WQS. Although water bodies can become impaired from pollution (e.g. flow alterations and habitat degradation) and pollutants (e.g. nutrients, sediment, and metals), the CWA and Montana State Law (75-5-703) both require TMDL development for waters impaired only by pollutants. Section 303 also requires states to submit a list of impaired water bodies to EPA every two years. Prior to 2004, EPA and DEQ referred to this list as the 303(d) List.

Since 2004, EPA has requested that states combine the 303(d) List with the 305(b) report containing an assessment of Montana's water quality and its water quality programs. EPA refers to this new combined 303(d)/305(b) report as the Integrated Water Quality Report. The 303(d) List also includes identification of the probable cause(s) of the water quality impairment problems (e.g. pollutants such as metals, nutrients, sediment or temperature), and the suspected source(s) of the pollutants of concern (e.g. various land use activities). State law (MCA 75-5-702) identifies that a sufficient credible data methodology for determining the impairment status of each water body is used for consistency; the actual methodology is identified in DEQ's Water Quality Assessment Process and Methods (DEQ 2006b). This methodology was developed via a public process and was incorporated into the EPA-approved 2000 version of the 305(b) report (now also referred to as the Integrated Report).

Under Montana State Law, an "impaired water body" is defined as a water body or stream segment for which sufficient credible data show that the water body or stream segment is failing to achieve compliance with applicable WQS (Montana Water Quality Act; Section 75-5-103(11)). A "threatened water body" is defined as a water body or stream segment for which sufficient credible data and calculated increases in loads show that the water body or stream segment is fully supporting its designated uses, but threatened for a particular designated use because of either (a) proposed sources that are not subject to pollution prevention or control actions required by a discharge permit, the nondegradation provisions, or reasonable land, soil, and water conservation practices or (b) documented adverse pollution trends (Montana WQA; Section 75-5-103(31)). State Law and Section 303 of the CWA require states to develop all necessary TMDLs for impaired or threatened water bodies. There are no threatened water bodies within the Upper Jefferson TPA.

A TMDL is a pollutant budget for a water body identifying the maximum amount of the pollutant that a water body can assimilate without causing applicable WQS to be exceeded. TMDLs are often expressed in terms of an amount, or load, of a particular pollutant (expressed in

units of mass per time such as pounds per day). TMDLs must account for loads/impacts from point and nonpoint sources in addition to natural background sources and must incorporate a margin of safety and consider influences of seasonality on analysis and compliance with WQS.

To satisfy the Federal CWA and Montana State Law, TMDLs will be developed for each water body-pollutant combination identified on Montana's 2006 303(d) List of impaired waters in the Upper Jefferson TPA. State Law (Administrative Rules of Montana 75-5-703(8)) also directs Montana DEQ to "...support a voluntary program of reasonable land, soil, and water conservation practices to achieve compliance with water quality standards for nonpoint source activities for water bodies that are subject to a TMDL…" This is an important directive that is reflected in the overall TMDL development and implementation strategy within this plan. It is important to note that water quality protection measures are not considered voluntary where such measures are already a requirement under existing Federal, State, or local regulations.

2.0 Applicable Water Quality Standards

WQS include the uses designated for a water body, the legally enforceable standards that ensure that the uses are supported, and a non-degradation policy that protects the high quality of a water body. The ultimate goal of this TMDL document, once implemented, is to ensure that all designated beneficial uses are fully supported and all standards are met. Water quality standards form the basis for the targets described in **Section 5.4.1**. Pollutants addressed in this Water Quality Planning Framework include: sediment. This section provides a summary of the applicable water quality standards for this pollutant.

2.1 Classification and Beneficial Uses

Classification is the assignment (designation) of a single or group of uses to a water body based on the potential of the water body to support those uses. Designated Uses or Beneficial Uses are simple narrative descriptions of water quality expectations or water quality goals. There are a variety of “uses” of state waters including growth and propagation of fish and associated aquatic life; drinking water; agriculture; industrial supply; and recreation and wildlife. The Montana WQA directs the BER (i.e., the state) to establish a classification system for all waters of the state that includes their present (when the Act was originally written) and future most beneficial uses (ARM 17.30.607-616) and to adopt standards to protect those uses (ARM 17.30.620-670).

Montana, unlike many other states, uses a watershed based classification system with some specific exceptions. As a result, *all* waters of the state are classified and have designated uses and supporting standards. All classifications have multiple uses and in only one case (A-Closed) is a specific use (drinking water) given preference over the other designated uses. Some waters may not actually be used for a specific designated use, for example as a public drinking water supply; however, the quality of that water body must be maintained suitable for that designated use. When natural conditions limit or preclude a designated use, permitted point source discharges or non-point source activities or pollutant discharges may not make the natural conditions worse.

Modification of classifications or standards that would lower a water’s classification or a standard (i.e., B-1 to a B-3), or removal of a designated use because of natural conditions can only occur if the water was originally misclassified. All such modifications must be approved by the BER, and are undertaken via a Use Attainability Analysis (UAA) that must meet EPA requirements (40 CFR 131.10(g), (h) and (j)). The UAA and findings presented to the BER during rulemaking must prove that the modification is correct and all existing uses are supported. An existing use cannot be removed or made less stringent.

Descriptions of Montana’s surface water classifications and designated beneficial uses are presented in **Table B-1**. All water bodies within the Upper Jefferson TPA are classified as B-1 (see **Section 3.1, Table 3-1** for individual stream classifications).

Table B-1. Montana Surface Water Classifications and Designated Beneficial Uses

Classification	Designated Uses
A-CLOSED CLASSIFICATION:	Waters classified A-Closed are to be maintained suitable for drinking, culinary and food processing purposes after simple disinfection.
A-1 CLASSIFICATION:	Waters classified A-1 are to be maintained suitable for drinking, culinary and food processing purposes after conventional treatment for removal of naturally present impurities.
B-1 CLASSIFICATION:	Waters classified B-1 are to be maintained suitable for drinking, culinary and food processing purposes after conventional treatment; bathing, swimming and recreation; growth and propagation of salmonid fishes and associated aquatic life, waterfowl and furbearers; and agricultural and industrial water supply.
B-2 CLASSIFICATION:	Waters classified B-2 are to be maintained suitable for drinking, culinary and food processing purposes after conventional treatment; bathing, swimming and recreation; growth and marginal propagation of salmonid fishes and associated aquatic life, waterfowl and furbearers; and agricultural and industrial water supply.
B-3 CLASSIFICATION:	Waters classified B-3 are to be maintained suitable for drinking, culinary and food processing purposes after conventional treatment; bathing, swimming and recreation; growth and propagation of non-salmonid fishes and associated aquatic life, waterfowl and furbearers; and agricultural and industrial water supply.
C-1 CLASSIFICATION:	Waters classified C-1 are to be maintained suitable for bathing, swimming and recreation; growth and propagation of salmonid fishes and associated aquatic life, waterfowl and furbearers; and agricultural and industrial water supply.
C-2 CLASSIFICATION:	Waters classified C-2 are to be maintained suitable for bathing, swimming and recreation; growth and marginal propagation of salmonid fishes and associated aquatic life, waterfowl and furbearers; and agricultural and industrial water supply.
C-3 CLASSIFICATION:	Waters classified C-3 are to be maintained suitable for bathing, swimming and recreation; growth and propagation of non-salmonid fishes and associated aquatic life, waterfowl and furbearers. The quality of these waters is naturally marginal for drinking, culinary and food processing purposes, agriculture and industrial water supply.
I CLASSIFICATION:	The goal of the State of Montana is to have these waters fully support the following uses: drinking, culinary and food processing purposes after conventional treatment; bathing, swimming and recreation; growth and propagation of fishes and associated aquatic life, waterfowl and furbearers; and agricultural and industrial water supply.

2.2 Standards

In addition to the Use Classifications described above, Montana's WQS include numeric and narrative criteria as well as a nondegradation policy.

Numeric surface WQS have been developed for many parameters to protect human health and aquatic life. These standards are in the Department Circular WQB-7 (DEQ 2006a). The numeric human health standards have been developed for parameters determined to be toxic, carcinogenic, or harmful and have been established at levels to be protective of long-term (i.e., life long) exposures as well as through direct contact such as swimming.

The numeric aquatic life standards include chronic and acute values that are based on extensive laboratory studies including a wide variety of potentially affected species, a variety of life stages and durations of exposure. Chronic aquatic life standards are protective of long-term exposure to a parameter. The protection afforded by the chronic standards includes detrimental effects to reproduction, early life stage survival and growth rates. In most cases the chronic standard is more stringent than the corresponding acute standard. Acute aquatic life standards are protective of short-term exposures to a parameter and are not to be exceeded.

High quality waters are afforded an additional level of protection by the nondegradation rules (ARM 17.30.701 et. seq.,) and in statute (75-5-303 MCA). Changes in water quality must be "non-significant", or an authorization to degrade must be granted by the Department. However, under no circumstance may standards be exceeded. It is important to note that waters that meet or are of better quality than a standard are high quality for that parameter, and nondegradation policies apply to new or increased discharges to that the water body.

Narrative standards have been developed for substances or conditions for which sufficient information does not exist to develop specific numeric standards. The term "Narrative Standards" commonly refers to the General Prohibitions in ARM 17.30.637 and other descriptive portions of the surface WQS. The General Prohibitions are also called the "free from" standards; that is, the surface waters of the state must be free from substances attributable to discharges, including thermal pollution, that impair the beneficial uses of a water body. Uses may be impaired by toxic or harmful conditions (from one or a combination of parameters) or conditions that produce undesirable aquatic life. Undesirable aquatic life includes bacteria, fungi, and algae.

The standards applicable to the list of pollutants addressed in the Upper Jefferson TPA are summarized below. In addition to the standards below, the beneficial use support standard for B-1 streams, as defined above, can apply to other conditions, often linked to pollution, limiting aquatic life. These other conditions can include impacts from dewatering/flow alterations, impacts from habitat modifications, or impacts from excess algae.

Sediment

Sediment (i.e., coarse and fine bed sediment) and suspended sediment are addressed via the narrative criteria identified in **Table B-2**. The relevant narrative criteria do not allow for harmful or other undesirable conditions related to increases above naturally occurring levels or from discharges to state surface waters. This is interpreted to mean that water quality goals should strive toward a condition in which any increases in sediment above naturally occurring levels are not harmful, detrimental or injurious to beneficial uses (see definitions in **Table B-2**).

Table B-2. Applicable Rules for Sediment Related Pollutants.

Rule(s)	Standard
17.30.623(2)	No person may violate the following specific water quality standards for waters classified B-1.
17.30.623(2)(f)	No increases are allowed above naturally occurring concentrations of sediment or suspended sediment (except a permitted in 75-5-318, MCA), settleable solids, oils, or floating solids, which will or are likely to create a nuisance or render the waters harmful, detrimental, or injurious to public health, recreation, safety, welfare, livestock, wild animals, birds, fish, or other wildlife.
17.30.637(1)	State surface waters must be free from substances attributable to municipal, industrial, agricultural practices or other discharges that will.
17.30.637(1)(a)	Settle to form objectionable sludge deposits or emulsions beneath the surface of the water or upon adjoining shorelines.
17.30.637(1)(d)	Create concentrations or combinations of materials that are toxic or harmful to human, animal, plant, or aquatic life.
	The maximum allowable increase above naturally occurring turbidity is: 0 NTU for A-closed; 5 NTU for A-1, B-1, and C-1; 10 NTU for B-2, C-2, and C-3)
17.30.602(17)	"Naturally occurring" means conditions or material present from runoff or percolation over which man has no control or from developed land where all reasonable land, soil, and water conservation practices have been applied.
17.30.602(21)	"Reasonable land, soil, and water conservation practices" means methods, measures, or practices that protect present and reasonably anticipated beneficial uses. These practices include but are not limited to structural and nonstructural controls and operation and maintenance procedures. Appropriate practices may be applied before, during, or after pollution-producing activities.

Turbidity

The allowable changes in turbidity (above natural) is a rather small 5 or 10 nephelometric turbidity units (NTU), see **Table B-2**. The likely direct effects of increased turbidity are on recreation and aesthetics and drinking water supplies. Indirectly increased turbidity can be linked to an increased pathogen potential, total recoverable metals concentration and increased total suspended sediment. Turbidity cannot be equated with other parameters. Turbidity is a measure of light scatter in water. Suspended or colloidal solids like phytoplankton, metal precipitates or clay may cause the light scatter. In some cases it may be a useful and easily measured surrogate for total suspended solids (TSS) but only after paired flow and seasonal (full hydrograph) turbidity and TSS data have been collected and a statistically significant correlation exists.

3.0 Reference Conditions

3.1 Reference Conditions as Defined in DEQ's Standard Operating Procedure for Water Quality Assessment (2006b)

DEQ uses the reference condition to evaluate compliance with many of the narrative WQS. The term "reference condition" is defined as the condition of a water body capable of supporting its present and future beneficial uses when all reasonable land, soil, and water conservation practices have been applied. In other words, reference condition reflects a water body's greatest potential for water quality given historic land use activities.

DEQ applies the reference condition approach for making beneficial use-support determinations for certain pollutants (such as sediment) that have specific narrative standards. All classes of waters are subject to the provision that there can be no increase above naturally occurring concentrations of sediment and settleable solids, oils, or floating solids sufficient to create a nuisance or render the water harmful, detrimental, or injurious. These levels depend on site-specific factors, so the reference conditions approach is used.

Also, Montana WQS do not contain specific provisions addressing nutrients (nitrogen and phosphorous), or detrimental modifications of habitat or flow. However, these factors are known to adversely affect beneficial uses under certain conditions or combination of conditions. The reference conditions approach is used to determine if beneficial uses are supported when nutrients, flow, or habitat modifications are present.

Water bodies used to determine reference condition are not necessarily pristine or perfectly suited to giving the best possible support to all possible beneficial uses. Reference condition also does not reflect an effort to turn the clock back to conditions that may have existed before human settlement, but is intended to accommodate natural variations in biological communities, water chemistry, etc. due to climate, bedrock, soils, hydrology, and other natural physiochemical differences. The intention is to differentiate between natural conditions and widespread or significant alterations of biology, chemistry, or hydrogeomorphology due to human activity. Therefore, reference conditions should reflect minimum impacts from human activities. It attempts to identify the potential condition that could be attained (given historical land use) by the application of reasonable land, soil, and water conservation practices. DEQ realizes that presettlement water quality conditions usually are not attainable.

Comparison of conditions in a water body to reference water body conditions must be made during similar season and/or hydrologic conditions for both waters. For example, the Total Suspended Solids (TSS) of a stream at base flow during the summer should not be compared to the TSS of reference condition that would occur during a runoff event in the spring. In addition, a comparison should not be made to the lowest or highest TSS values of a reference site, which represent the outer boundaries of reference conditions.

The following methods may be used to determine reference conditions:

Primary Approach

- Comparing conditions in a water body to baseline data from minimally impaired water bodies that are in a nearby watershed or in the same region having similar geology, hydrology, morphology, and/or riparian habitat.
- Evaluating historical data relating to condition of the water body in the past.
- Comparing conditions in a water body to conditions in another portion of the same water body, such as an unimpaired segment of the same stream.

Secondary Approach

- Reviewing literature (e.g. a review of studies of fish populations, etc., that were conducted on similar water bodies that are least impaired.
- Seeking expert opinion (e.g. expert opinion from a regional fisheries biologist who has a good understanding of the water body's fisheries health or potential).
- Applying quantitative modeling (e.g. applying sediment transport models to determine how much sediment is entering a stream based on land use information, etc.).

DEQ uses the primary approach for determining reference condition if adequate regional reference data are available and uses the secondary approach to estimate reference condition when there is no regional data. DEQ often uses more than one approach to determine reference condition, especially when regional reference condition data are sparse or nonexistent.

B.3.2 Use of Statistics for Developing Reference Values or Ranges

Reference value development must consider natural variability as well as variability that can occur as part of field measurement techniques. Statistical approaches are commonly used to help incorporate variability. One statistical approach is to compare stream conditions to the mean (average) value of a reference data set to see if the stream condition compares favorably to this value or falls within the range of one standard deviation around the reference mean. The use of these statistical values assumes a normal distribution; whereas, water resources data tend to have a non-normal distribution (Hensel and Hirsch 1995). For this reason, another approach is to compare stream conditions to the median value of a reference data set to see if the stream condition compares favorably to this value or falls within the range defined by the 25th and 75th percentiles of the reference data. This is a more realistic approach than using one standard deviation since water quality data often include observations considerably higher or lower than most of the data. Very high and low observations can have a misleading impact on the statistical summaries if a normal distribution is incorrectly assumed, whereas statistics based on non-normal distributions are far less influenced by such observations.

Figure B-1 is an example boxplot type presentation of the median, 25th and 75th percentiles, and minimum and maximum values of a reference data set. In this example, the reference stream results are stratified by two different stream types. Typical stratifications for reference stream data may include Rosgen stream types, stream size ranges, or geology. If the parameter being measured is one where low values are undesirable and can cause harm to aquatic life, then measured values in the potentially impaired stream that fall below the 25th percentile of reference data are not desirable and can be used to indicate impairment. If the parameter being measured is

one where high values are undesirable, then measured values above the 75th percentile can be used to indicate impairment.

The use of a non-parametric statistical distribution for interpreting narrative WQS or developing numeric criteria is consistent with EPA guidance for determining nutrient criteria (EPA 2000). Furthermore, the selection of the applicable 25th or 75th percentile values from a reference data set is consistent with ongoing DEQ guidance development for interpreting narrative WQS where it is determined that there is "good" confidence in the quality of the reference sites and resulting information (DEQ 2004). If it is determined that there is only a "fair" confidence in the quality of the reference sites, then the 50th percentile or median value should be used, and if it is determined that there is "very high" confidence, then the 90th percentile of the reference data set should be used. Most reference data sets available for water quality restoration planning and related TMDL development, particularly those dealing with sediment and habitat alterations, would tend to be "fair" to "good" quality. This is primarily due to a the limited number of available reference sites/data points available after applying all potentially applicable stratifications on the data, inherent variations in monitoring results among field crews, the potential for variations in field methodologies, and natural yearly variations in stream systems often not accounted for in the data set.

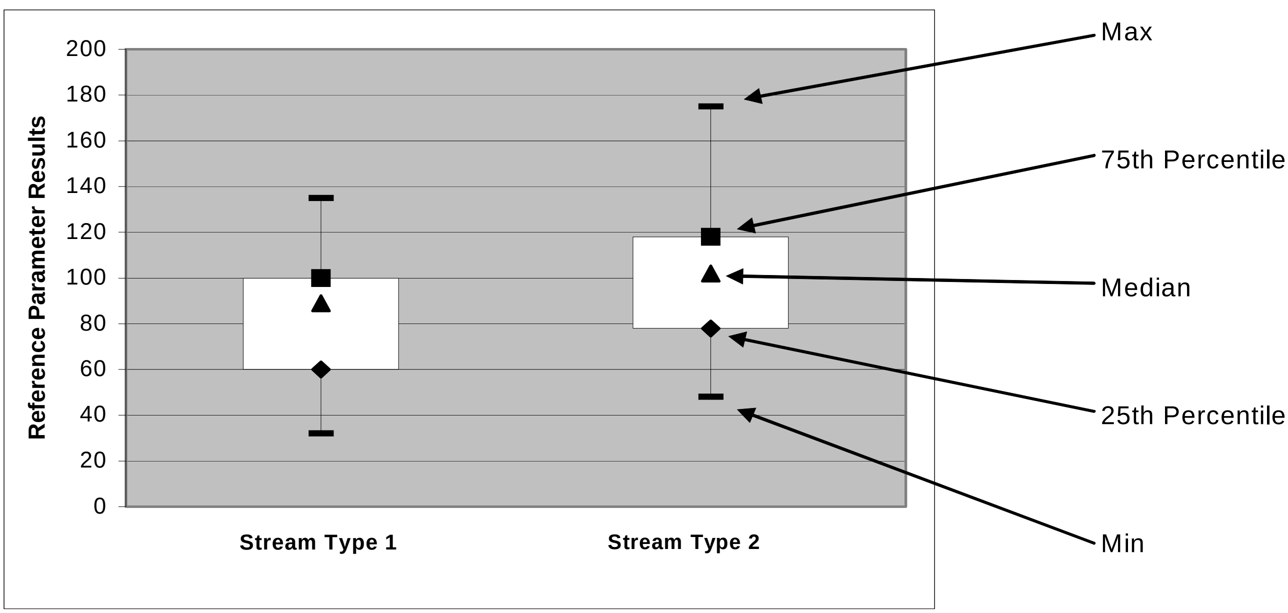

Figure B-1. Boxplot Example for Reference Data.

The above 25th – 75th percentile statistical approach has several considerations:

1. It is a simple approach that is easy to apply and understand.
2. About 25 percent of all streams would naturally fall into the impairment range. Thus, it should not be applied unless there is some linkage to human activities that could lead to the observed conditions. Where applied, it must be noted that the stream's potential may prevent it from achieving the reference range as part of an adaptive management plan.

3. About 25 percent of all streams would naturally have a greater water quality potential than the minimum water quality bar represented by the 25^{th} to 75^{th} percentile range. This may represent a condition where the stream's potential has been significantly underestimated. Adaptive management can also account for these considerations.
4. Obtaining reference data that represents a naturally occurring condition can be difficult, particularly for larger water bodies with multiple land uses within the drainage. This is because all reasonable land, soil, and water conservation practices may not be in place in many larger water bodies across the region. Even if these practices are in place, the proposed reference stream may not have fully recovered from past activities, such as riparian harvest, where reasonable land, soil, and water conservation practices were not applied.
5. A stream should not be considered impaired unless there is a relationship between the parameter of concern and the beneficial use such that not meeting the reference range is likely to cause harm or other negative impacts to the beneficial use as described by the WQS in **Table B-2**. In other words, if not meeting the reference range is not expected to negatively impact aquatic life, cold water fish, or other beneficial uses, then an impairment determination should not be made based on the particular parameter being evaluated. Relationships that show an impact to the beneficial use can be used to justify impairment based on the above statistical approach.

As identified in (2) and (3) above, there are two types of errors that can occur due to this or similar statistical approaches where a reference range or reference value is developed: (1) A stream could be considered impaired even though the naturally occurring condition for that stream parameter does not meet the desired reference range or (2) a stream could be considered not impaired for the parameter(s) of concern because the results for a given parameter fall just within the reference range, whereas the naturally occurring condition for that stream parameter represents much higher water quality and beneficial uses could still be negatively impacted. The implications of making either of these errors can be used to modify the above approach, although the approach used will need to be protective of water quality to be consistent with DEQ guidance and WQS (DEQ 2004). Either way, adaptive management is applied to this water quality plan and associated TMDL development to help address the above considerations.

Where the data does suggest a normal distribution, or reference data is presented in a way that precludes use of non-normal statistics, the above approach can be modified to include the mean plus or minus one standard deviation to provide a similar reference range with all of the same considerations defined above.

Options When Regional Reference Data is Limited or Does Not Exist

In some cases, there is very limited reference data and applying a statistical approach like above is not possible. Under these conditions, the limited information can be used to develop a reference value or range, with the need to note the greater level of uncertainty and perhaps a greater level of future monitoring as part of the adaptive management approach. These conditions can also lead to more reliance on secondary type approaches for reference development as defined in **Section 1.3.1**.

Another approach would be to develop statistics for a given parameter from all streams within a watershed or region of interest (EPA 2000). The boxplot distribution of all the data for a given parameter can still be used to help determine potential target values knowing that most or all of the streams being evaluated are either impaired or otherwise have a reasonable probability of having significant water quality impacts. Under these conditions you would still use the median and the 25th or 75th percentiles as potential target values, but you would use the 25th and 75th percentiles in a way that is opposite from how you use the results from a regional reference distribution. This is because you are assuming that, for the parameter being evaluated, as many as 50 percent to 75 percent of the results from the whole data distribution represent questionable water quality. **Figure B-2** is an example statistical distribution where higher values represent better water quality. In **Figure B-2**, the median and 25th percentiles represent potential target values versus the median and 75th percentiles discussed above for regional reference distribution. Whether you use the median, the 25th percentile, or both should be based on an assessment of how impacted all the measured streams are in the watershed. Additional consideration of target achievability is important when using this approach. Also, there may be a need to also rely on secondary reference development methods to modify how you apply the target and/or to modify the final target value(s). Your certainty regarding indications of impairment or non-impairment may be lower using this approach, and you may need to rely more on adaptive management as part of TMDL implementation.

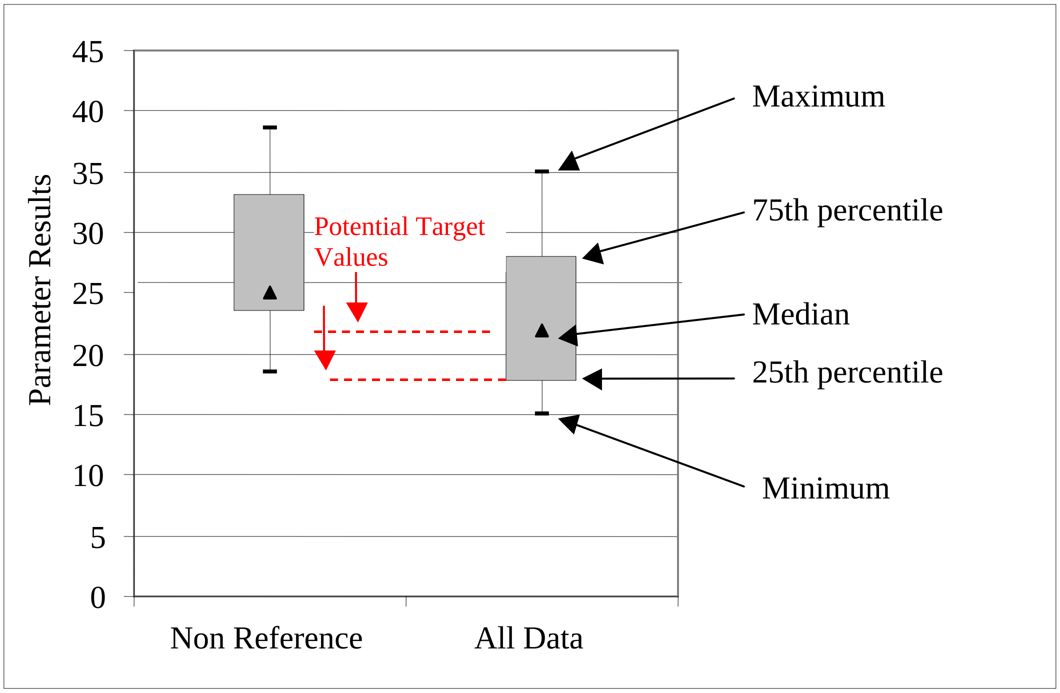

Figure B-2. Boxplot example for the use of all data to set targets.

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APPENDIX C
2004 AERIAL PHOTO REVIEW AND FIELD SOURCE ASSESSMENT, UPPER JEFFERSON RIVER WATERSHED

1.0 INTRODUCTION

The Montana Department of Environmental Quality (DEQ) is required to develop a TMDL water quality restoration plan by 2005 for all threatened or impaired waters within the Upper Jefferson TMDL planning unit, in order to satisfy state law as well as federal court requirements. The Upper Jefferson planning unit includes the mainstem Jefferson River to the confluence with the Boulder River (42 miles) and the tributary drainages: Big Pipestone, Cherry, Dry Boulder, Fish, Fitz, Halfway, Hells Canyon, Little Pipestone, and Whitetail creeks. The Jefferson River and some portion of all of the above listed tributaries were included on DEQ's *1996 303(d) List of Impaired and Threatened Waterbodies in Need of Water Quality Restoration*. In 2000, 2002, and 2004, Big Pipestone, Fish, Hells Canyon, Little Pipestone, and Whitetail creeks and the Jefferson River were included on DEQ's 303(d) List as requiring TMDLs. Cherry, Dry Boulder, Fitz, and Halfway creeks have been listed as waters requiring reassessment (sufficient credible data).

1.1 Upper Jefferson Watershed 2004 Aerial Photo Review and Field Source Assessment

In 2004, Land & Water conducted an aerial photo and field source assessment with the intent of identifying pollution sources and the magnitude and locations of water quality impairments associated with sediment, nutrients, metals, water temperature, and riparian and aquatic habitat degradation. Project goals included 1) identifying major sources of pollution to the 303(d) Listed streams, 2) detecting channel, riparian, and landuse changes over time, 3) creation of a spatial database for inventorying photo availability and the source assessment, and 4) field verification and further refinement of source identification. The investigation consisted of two phases: 1) an assessment of available current and historic aerial photographs, digital imagery and topographic maps, and 2) photo and field data collection.

1.1.1 Assessment Methodology

The first phase of the project involved the collection of historic and current aerial photographs and relevant GIS data, including digital imagery and data layers pertaining to the Upper Jefferson Watershed. Many GIS layers for the project area were compiled during Land & Water's 2003 Jefferson River Watershed Characterization and Water Quality Status Review effort, so that much of the effort focused on gathering historic and current images of the 303(d) Listed streams in the Upper Jefferson Watershed. Photographs were sought from the Beaverhead-Deer Lodge National Forest, the Jefferson River Watershed Council, the Montana Natural Resources Conservation Service (Whitehall Field Office), the Montana Department of Natural Resources and Conservation, the USDA Historic Photo Repository, the Montana Natural Resource Information Service, and the Montana Department of Transportation.

The second phase of the project entailed the actual aerial and field source assessment of the 303(d) Listed streams in the Upper Jefferson Watershed. The source assessment methodology followed protocols established in the *Upper Jefferson River Water Quality Monitoring Project Quality Assurance Project Plan* (Land & Water, 2004). The focus of the aerial inventory was to detect pollution sources and quantify changes in stream channel features and riparian vegetation

for the 303(d) Listed streams on a stream reach basis. Previously collected data, such as published reports and GIS layers (i.e. geomorphology, potential pollution sources), were used to aid the evaluation. All of the assessment generated data were assembled in a GIS database, a geodatabase. The geodatabase allowed for the information to be analyzed for changes over time; provided for attribute mapping of the information; and can also be used to store future information.

Portions of all the 303(d) Listed streams were visited in the field in October of 2004, except for the Jefferson River. No field assessment was done on the Jefferson River due to the detailed Jefferson River Riparian Inventory conducted by Hoitsma Ecological in 2003. The purpose of the field based source assessment was to 1) ground truth and add further detail to the results of the air-photo interpretation, 2) to rank and prioritize source categories affecting each stream segment and impaired water uses, 3) to refine the delineation of impaired stream segments and, where appropriate, 4) to identify stream segments and source categories that may warrant additional source quantification work.

1.1.2 Photo Years and Source Assessment

For the photo collection effort, photos dating from 1942 to 2002 were acquired for some portion or all of the 303(d) Listed streams Upper Jefferson Watershed. In consideration of photo coverage, as well as budget and time constraints, only two time periods of imagery were analyzed, a 2000 time period and a 1980 time period. Photo inventory began with the photos from 2001 and 2002, because the recent period was expected to have the most accurate portrayal of existing stream conditions and pollution sources. **Table 1.1** lists the 303(d) stream segments, corresponding photo analysis years, and stream portions analyzed. Lack of complete photo coverage was the reason that some streams were not analyzed for their entire length.

Table 1-1. 303(d) Streams and Corresponding Photo Year Inventory

Stream	Photo Year	Scale	Portion of Stream Surveyed
Big Pipestone Creek	2001	1:15,840	Delmoe Lake to I-90 Crossing
	1982-1983	1:12,000	Delmoe Lake to Mouth
Cherry Creek	2001	1:15,840	Headwaters to Mouth
	1982-1983	1:12,000	Headwaters to Mouth
Dry Boulder Creek	2001	1:15,840	Headwaters to Mouth
	1982-1983	1:12,000	Headwaters to Mouth
Fish Creek	2001	1:15,840	Headwaters to Lowermost BLM Property (≈10 Miles)
	1982-1983	1:12,000	Headwaters to Jefferson Canal
Fitz Creek	1995	1:15,840	Headwaters to Mouth
	1983	1:12,000	Headwaters to Mouth
Halfway Creek	2001	1:15,840	Headwaters to Mouth
	1982-1983	1:12,000	Headwaters to Mouth

Table 1-1. 303(d) Streams and Corresponding Photo Year Inventory

Stream	Photo Year	Scale	Portion of Stream Surveyed
Hells Canyon Creek	2001	1:15,840	Headwaters to Mouth
	1983	1:12,000	Headwaters to Mouth
Little Pipestone Creek	2001	1:15,840	Headwaters to Beaverhead-Deerlodge NF Boundary (≈7 Miles)
	1982-1983	1:12,000	Headwaters to Mouth
Whitetail Creek	2001	1:15,840	Whitetail Reservoir to Boundary of State Owned Land (≈11 Miles)
	1983	1:12,000	Whitetail Reservoir to Mouth
Upper Jefferson River	2002	1:10,000*	Headwaters to the Boulder River
	1982-1983	1:12,000	≈2 Miles Below the Headwaters to the Boulder River

*Photo images were digital at 1 meter per pixel and 1 foot/pixel, but analysis was conducted in GIS at 1:10,000 scale.

1.1.3 Assessment Data Validation

Data validation for the aerial photo and field assessment data followed protocols established in the *Upper Jefferson River Preliminary Source Assessment Quality Assurance Project Plan* (Land & Water, 2004). Quality control for the data generated during the photo review involved accuracy checking of the planimeter, conducting repeat measurements, and ground truthing of selected reach segments during the field source assessment. Topographic maps and digital orthophotoquadrangles were used to assure that the proper streams were being assessed. Field quality control involved use of a differentially corrected GPS receiver. A database dictionary was developed that established standardized codes for collection of GPS source data in the field.

Measurement quality objectives for this project were set at a precision of ± 15 percent and an accuracy of ± 25 percent for all photo review data; while field generated data accuracy was set at ± 10 percent. Differences between measurements of different photos years should be evaluated with scale in mind. While the larger scale photos displayed more details, displacement and distortion of measurements were greater at larger scales (due to the greater effect of the curvature of the surface of the Earth). For guidance, the 1:12,000 scale photos are about 25 percent larger scale than the 1:15,840 scale photos, while measurements made in GIS at 1:10,000 are 20 percent larger scale than the 1:12,000 scale photos.

2.0 AERIAL PHOTO REVIEW AND FIELD SOURCE ASSESSMENT DATA RESULTS

2.1 Results of the Aerial Photo Collection and Compilation

Photos from 1942 to 2002 were acquired in digital format, scanned to digital format, or hard copies were ordered from the USDA Historic Photo Repository. In total 436 photo-image files and 34 hard copy photos were acquired for the Upper Jefferson Watershed. **Figures 2-1** to **2-6** display the results of the photo collection effort and corresponding photo coverage.

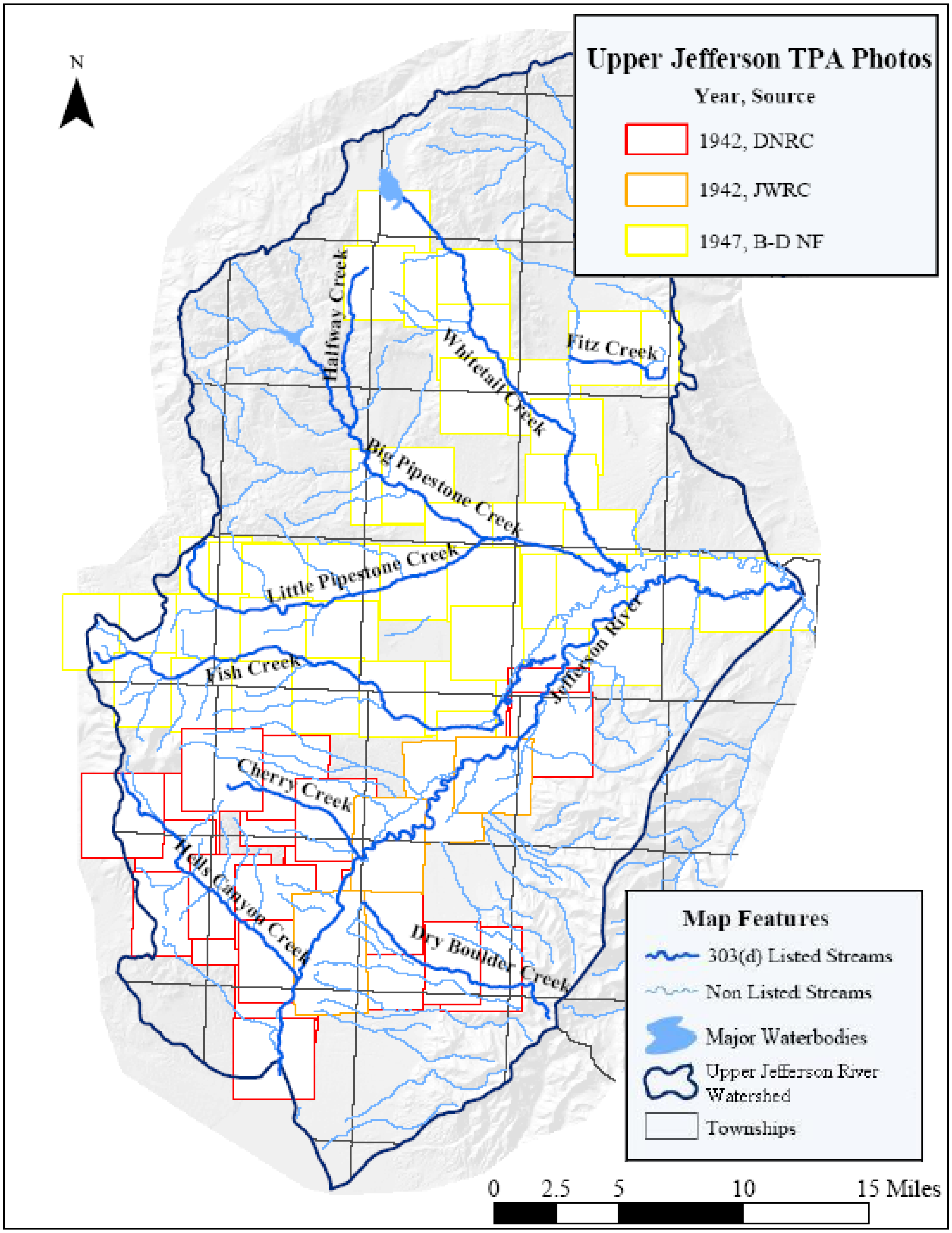

Figure 2-1. ***1940's Vintage Aerial Photo Coverage for the Upper Jefferson Watershed***

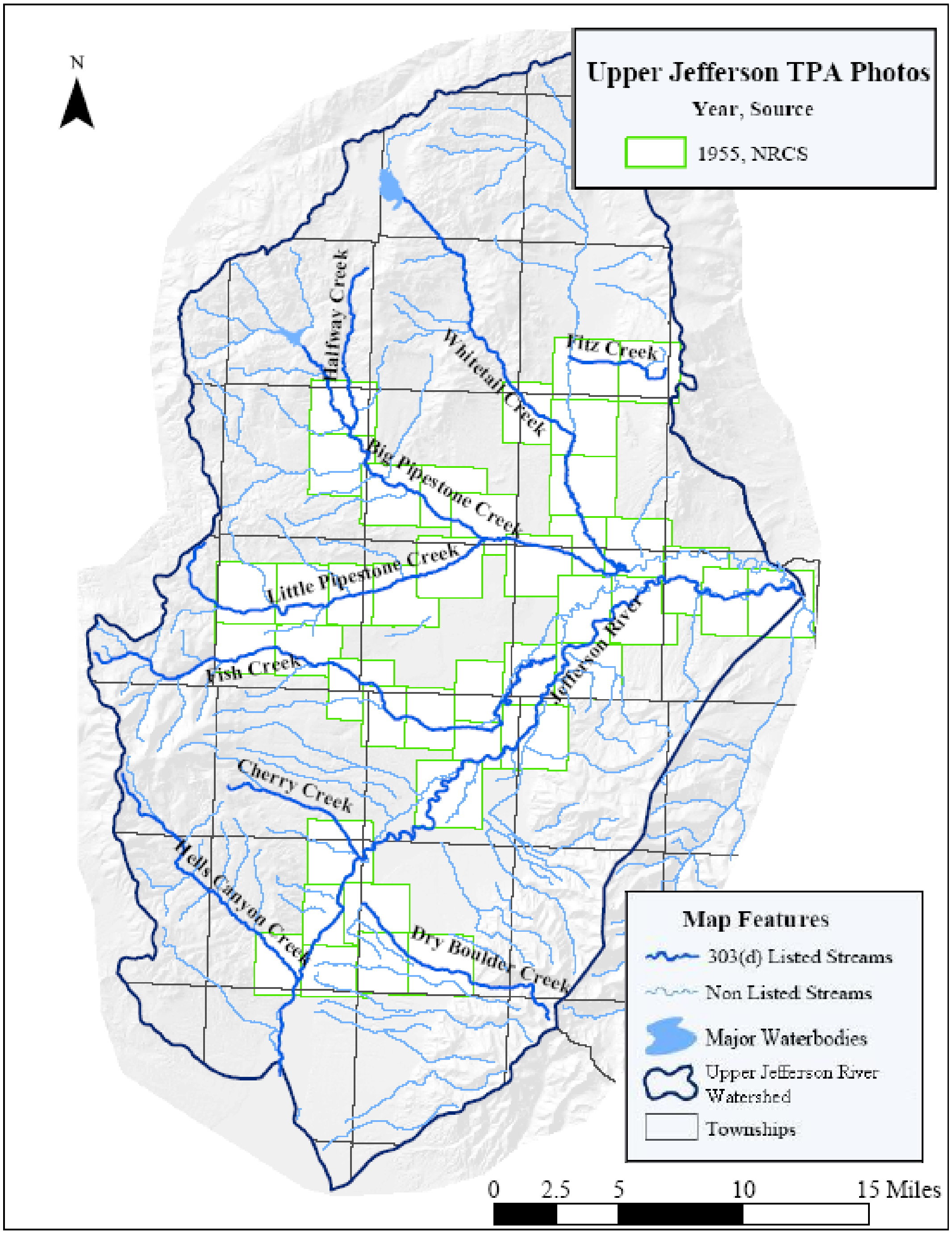

Figure 2-2. 1950's Vintage Aerial Photo Coverage for the Upper Jefferson Watershed

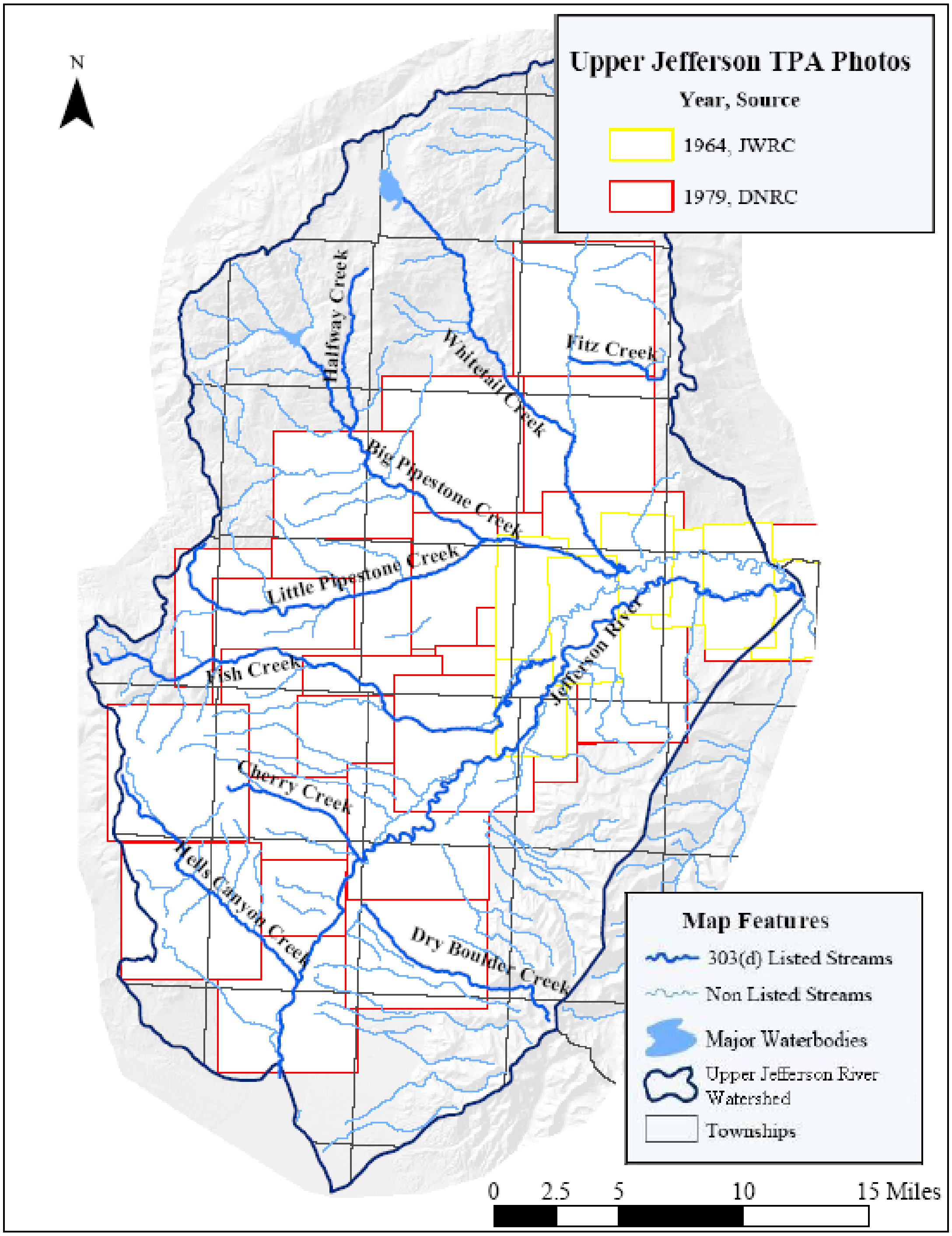

Figure 2-3. 1960's and 1970's Vintage Aerial Photo Coverage for the Upper Jefferson Watershed

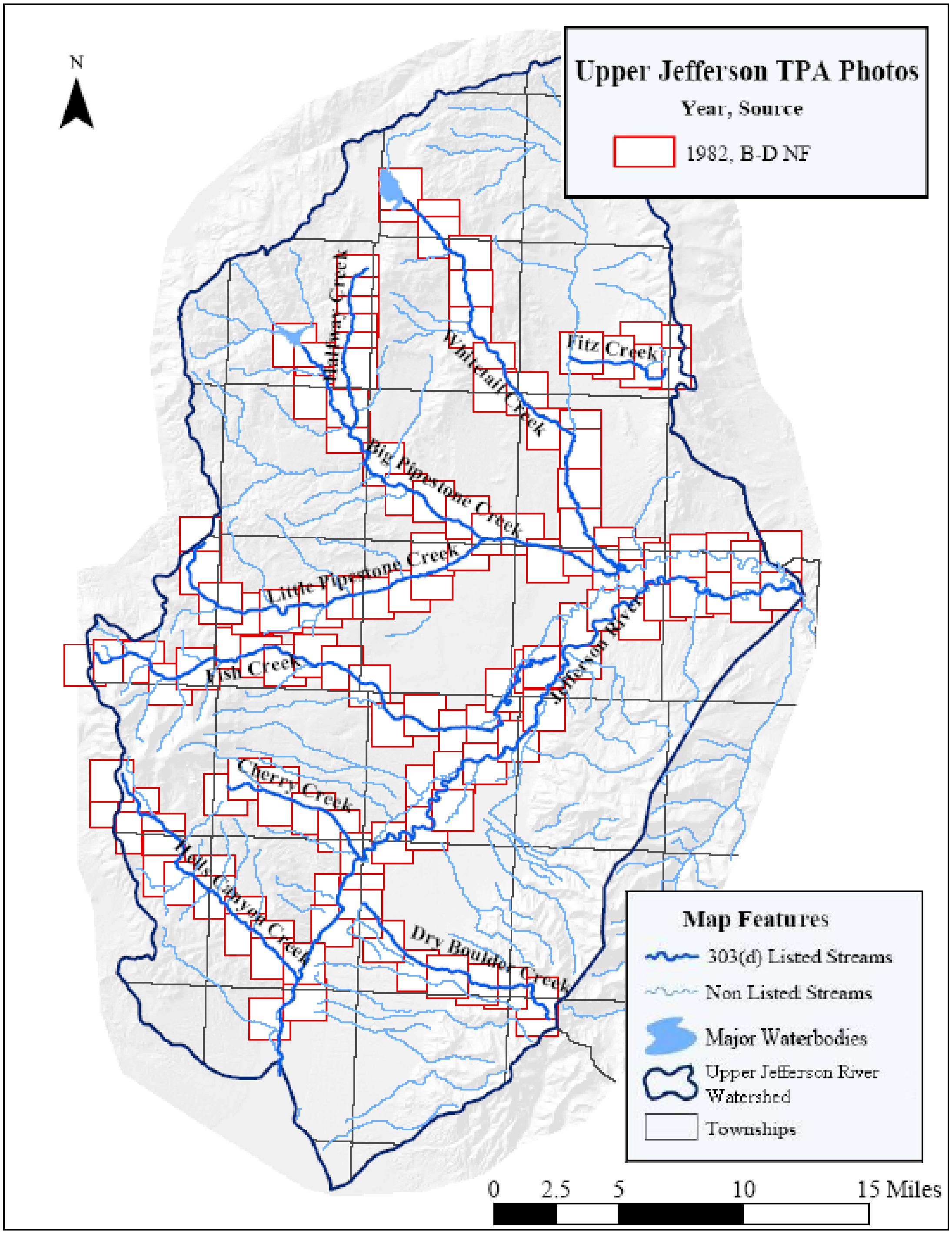

Figure 2-4. 1980's Vintage Aerial Photo Coverage for the Upper Jefferson Watershed

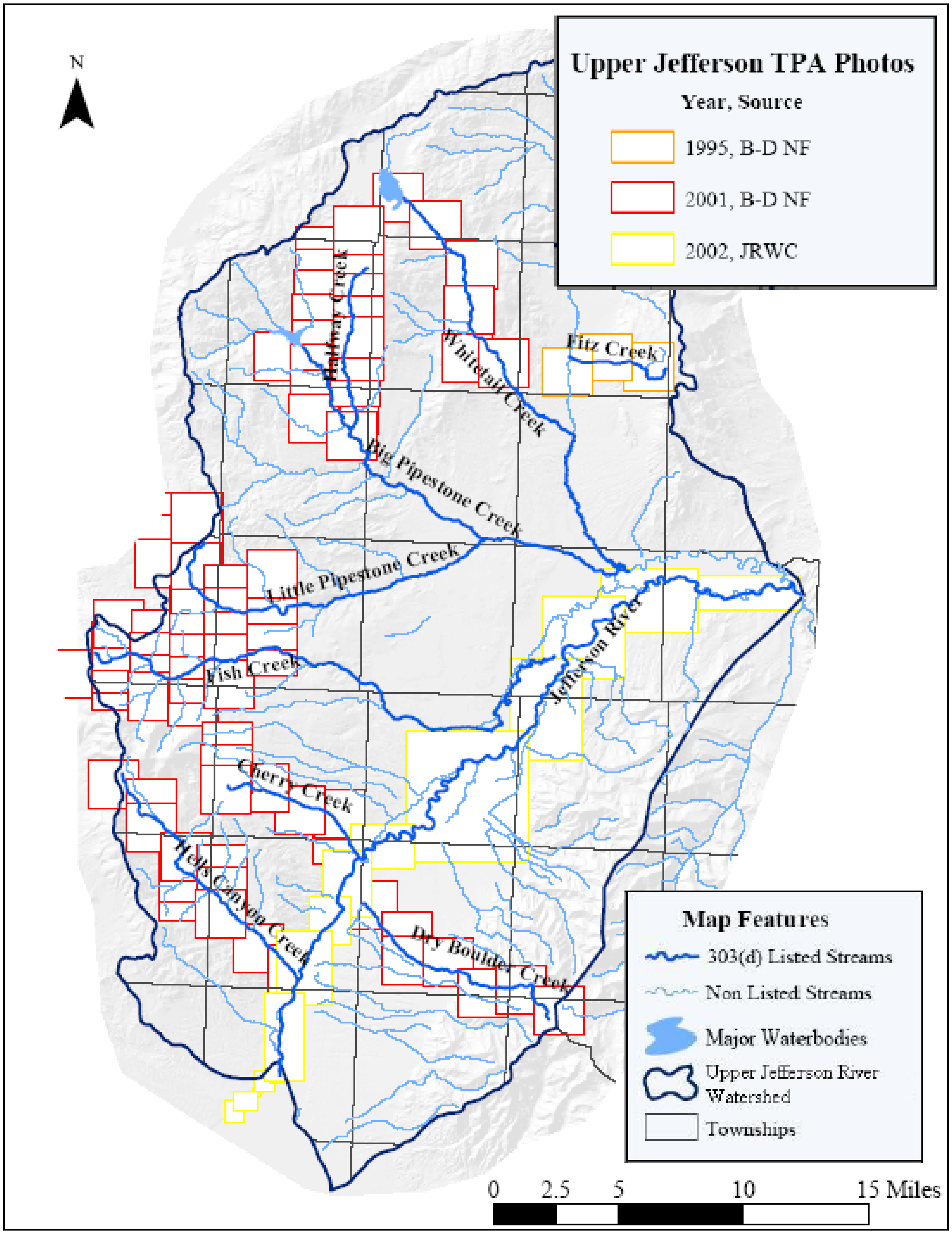

Figure 2-5. 1990's and 2000's Vintage Aerial Photo Coverage for the Upper Jefferson Watershed

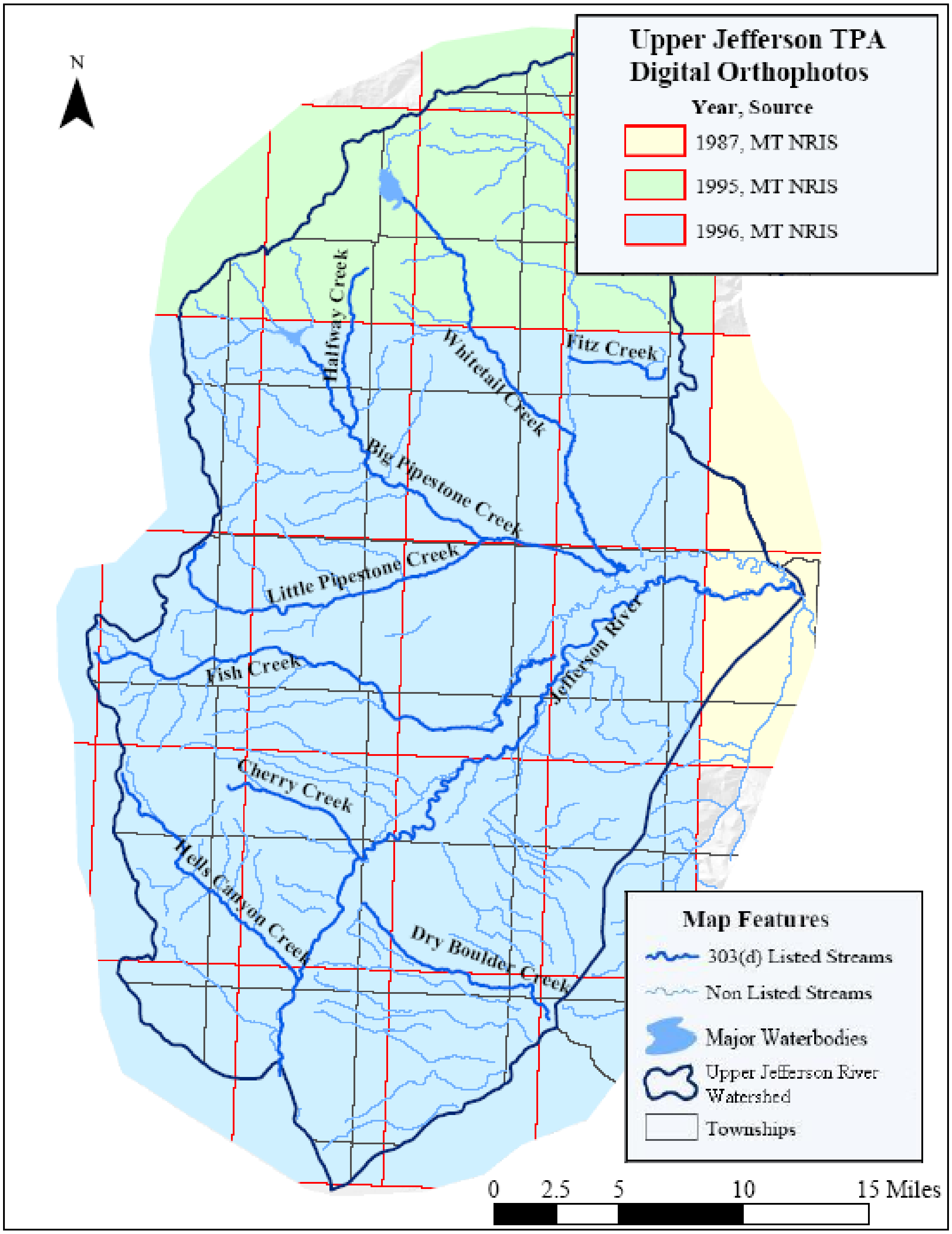

Figure 2-6. Digital Orthophoto Quadrangle Coverage for the Upper Jefferson Watershed

2.2 Results of the Aerial Photo Review and Field Source Assessment

The array of pollutant sources affecting the 303(d) Listed streams in the Upper Jefferson Watershed are a result of historic and current land use practices, as well as natural processes. The

magnitude of problems range from high to low severity and are found upslope from, adjacent to, and within the stream channels. The results of the 2004 aerial photo inventory and field source assessment data are presented in the following sections.

2.2.1 Big Pipestone Creek

Big Pipestone Creek forms at the outlet of Delmoe Lake on the Beaverhead-Deerlodge National Forest. It flows for approximately 20 miles to where it meets Whitetail Creek.
The suspected causes of impairment to Big Pipestone Creek are bank erosion, channel incisement, habitat degradation/alteration, nutrients, riparian degradation, suspended sediment, and thermal modifications. Suspected pollution sources to Big Pipestone Creek include agriculture, channelization, grazing related sources, habitat modification, hydromodification, municipal point sources, removal of riparian vegetation, road related sources, and silviculture. According to the 2004 303(d) List, cold water fisheries and associated aquatic life, industry, and primary contact recreation are partially supported uses.

For the purposes of the source assessment, Big Pipestone Creek was broken into 16 reaches (**Figures 2-7** to **2-12**). During the 2004 water quality monitoring project (May to September) and the October field source assessment, 9 of the 16 reaches were visited in the field (**Table 2-1**). Where available, field information was incorporated within the results of the source assessment.

Table 2-1. Field Assessment of Big Pipestone Creek Reaches

Big Pipestone Creek Reach Number	Visit Purpose	Percent of Reach Surveyed
Reach 1	Field Survey	10%
Reach 2	Field Survey, Water Quality Monitoring	10%
Reach 7	Water Quality Monitoring	Less than 10%
Reach 10	Field Survey	45%
Reach 11	Field Survey	Less than 10%
Reach 12	Field Survey	25%
Reach 13	Field Survey, Water Quality Monitoring	40%
Reach 14	Field Survey	40%
Reach 16	Water Quality Monitoring	5%

2.2.1.1 Big Pipestone Creek Rosgen Stream Types

The channel forms of Big Pipestone Creek above Interstate 90 are predominantly controlled by landform structure, as well as reservoir releases from Delmoe Lake (**Figure 2-7**). The prominent landform geology, the Boulder Batholith, has resulted in valley bottom formation along weathered joints. Narrow valley bottoms dominated by granitic boulders (B-type reaches), as well as less confined valley bottom areas are found (C-type reaches). Portions of Reaches 1 and 2 viewed during the field survey exhibited B and F channel types. B-type sections were found

where the stream was more structurally controlled (lower W/D ratio and less entrenched). After the field review, it was noted that Reach 1 could probably have been broken into 2 reaches as most of the reach appeared unconfined on the air photos, but only the upper 10 percent of the reach was viewed in the field (mostly F-type). The portion of Reach 7 viewed in the field exhibited a C-type channel. Delmoe Lake releases have greatly increased the flow of the creek. It is the professional opinion of the surveyor that without the lake releases natural channel form would alternate between B and Eb stream types. There were no significant changes in channel form between 1983 and 2001.

Many of the channel forms of Big Pipestone Creek below Interstate 90 are controlled by historical and current landuse activities (**Figure 2-8**). The predominant valley type (VIII) would typically result in an unconfined stream type (C or E), yet water level alterations for flow diversions and channelization have resulted in stream types out of balance with the valley type. Portions of Reaches 10, 12, and the upper part of Reach 13 viewed during the field survey exhibited C-type channels, while the portion of Reach 11 viewed, and some areas of Reach 12 exhibited E-type stream channels. Channel form in the valley was variable, with many areas observed as incised. Remnants of beaver dams were found in Reaches 10, 11, 12 and 13. From about the middle of Reach 13 to the mouth, numerous alterations to the channel have occurred, such that Rosgen stream typing is somewhat inapplicable (constructed channel versus alluvial channel). However, F-type sections were noted in Reaches 13 and 14. Reach 14 is where the stream was channelized for the railway. The channelization was probably the cause of extreme headcutting observed in this reach. At Reach 15, the stream appeared to return to its natural channel, while over half of Reach 16 appeared to be a constructed channel. The portion of Reach 16 viewed in the field appeared to be more of an E-type channel (low W/D ratio, no point bars), however stream type was classified as an F due to the large area of the reach not observed in proximity to the channelized reach (14). For the valley portion of Big Pipestone Creek, only one time period was analyzed so significant changes in channel form since 1983 could not be determined.

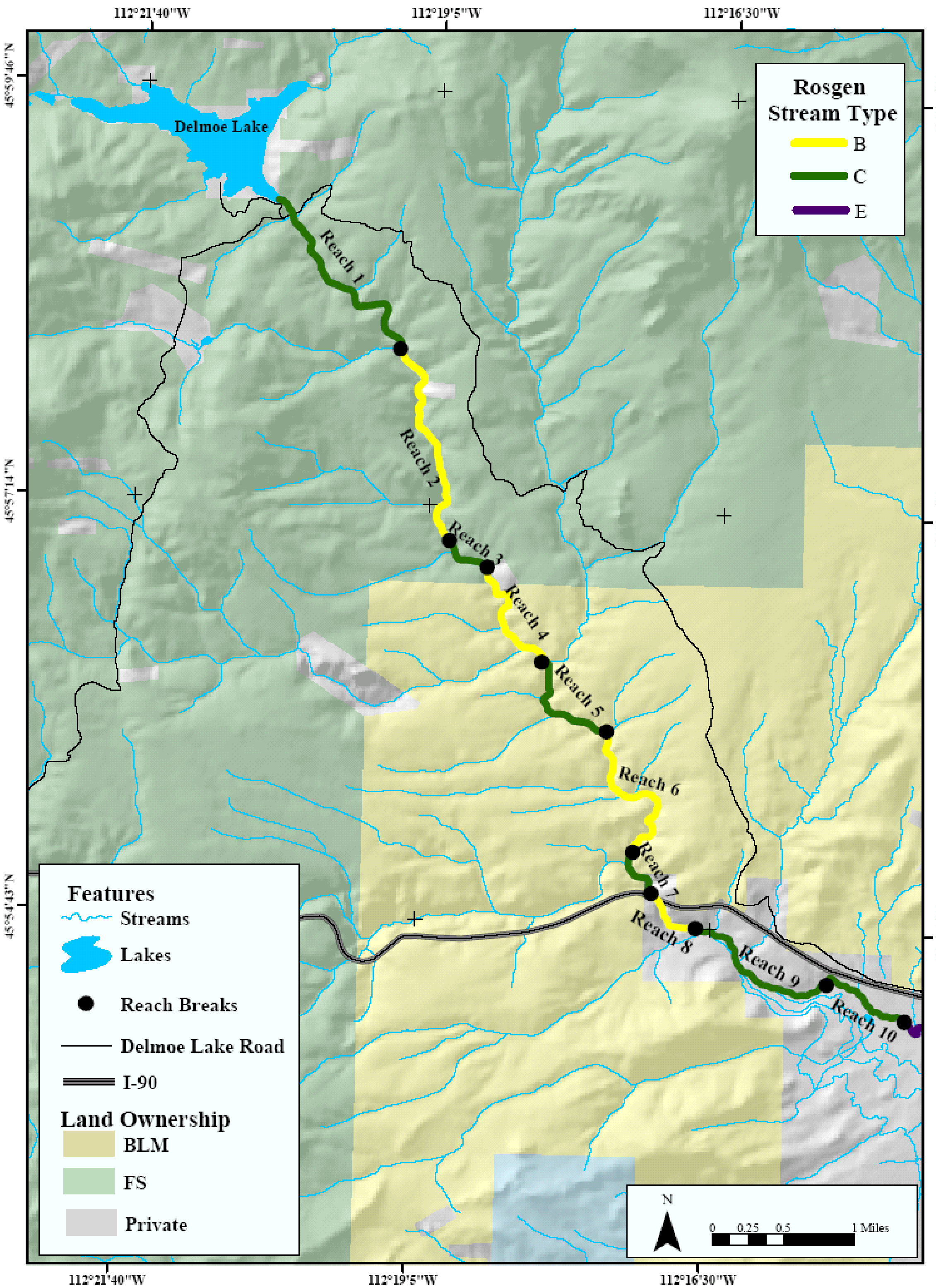

Figure 2-7. Upper Big Pipestone Creek Rosgen Stream Types

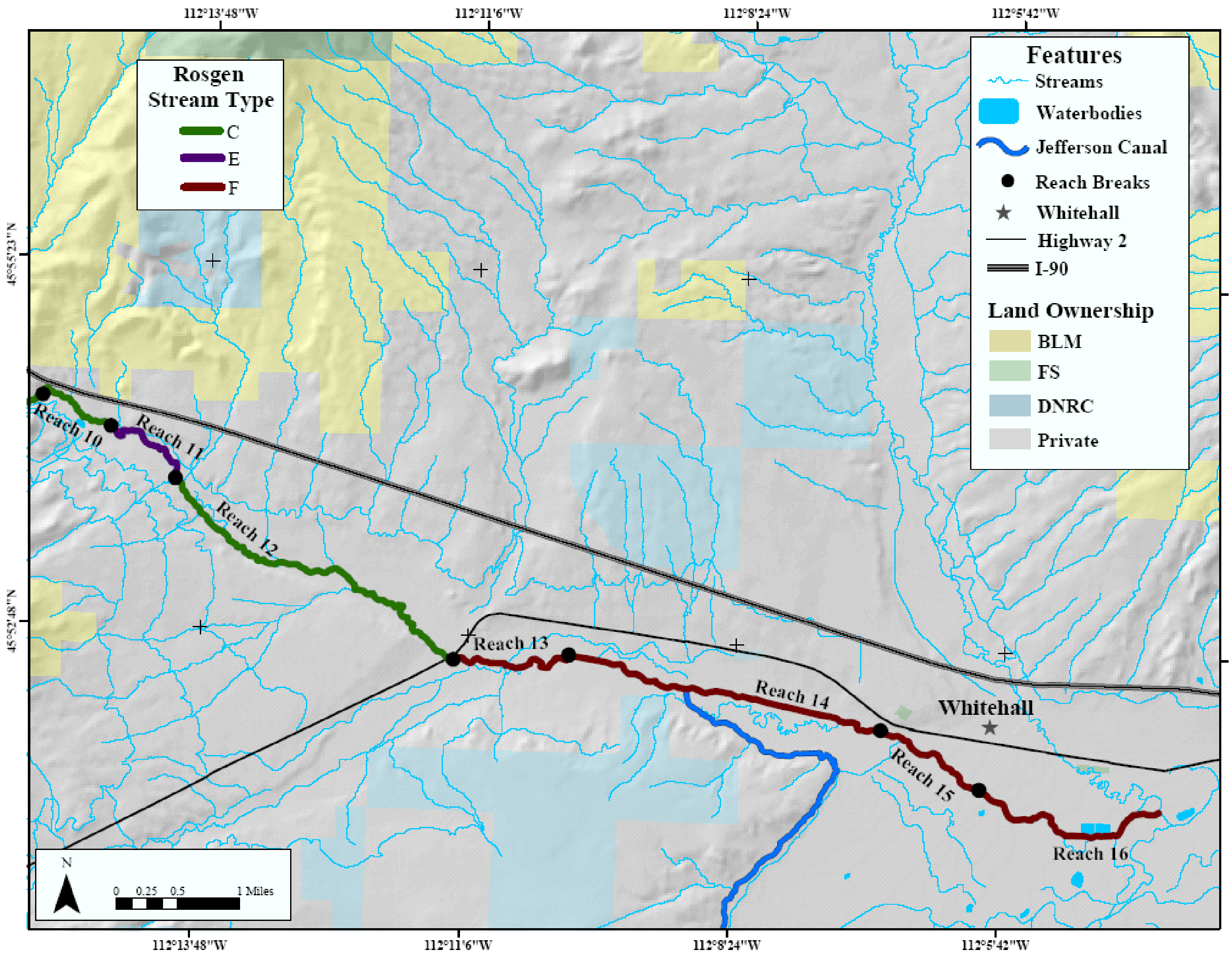

Figure 2-8. Lower Big Pipestone Creek Rosgen Stream Types

2.2.1.2 Big Pipestone Creek Riparian Vegetation

The dominant riparian cover along Big Pipestone Creek above Interstate 90 was mixed coniferous forest with upland shrubs (**Figure 2-9**). Buffer widths were generally greater than 100 feet wide along both sides of the stream. The buffer widths represented the distance of vegetation surrounding the stream before any disturbance was observed, as opposed to the actual width of 'wet' vegetation (alders, willows, etc.). The relative health category assigned to all of the upper reaches was: 'Fair. Vegetation appears healthy, but some disturbance is present.' During the field review, willows, alders, rose, red osier, and grasses were noted as extending to a maximum of 30 feet from the channel within the conifer forest. Some areas of thistle infestation were present. Between 1983 and 2001, the riparian buffer widths in Reaches 4 and 7 appeared to increase by an average of 25 percent.

The dominant riparian cover along Big Pipestone Creek below Interstate 90 was herbaceous; whereby, the grasses or forbs were being grown into the riparian and almost no woody vegetation was present (**Figure 2-10**). The one exception to this was Reach 11, which dominantly exhibited wetland characteristics. The buffer widths of these lower reaches represented the actual width of 'wet' vegetation (alders, willows, etc.). Buffer widths were generally less than 100 feet wide along both sides of the stream. The relative health category assigned to most of the valley reaches was: 'Fair. Vegetation appears healthy, but some disturbance is present.' Reaches 13, 14, and 16 were assigned a rating of 'Poor' due to notable disturbance. During the field review, willows, cottonwood, rose, and grasses were noted as extending generally to a maximum of 40 feet from the channel in Reaches 10 and 12. In Reaches 13 and 14, grasses, decadent willows, and roses were the predominant vegetation. Some areas of thistle and knapweed infestations were present. For the valley portion of Big Pipestone Creek, only one time period was analyzed so significant changes in riparian vegetation since 1983 could not be determined.

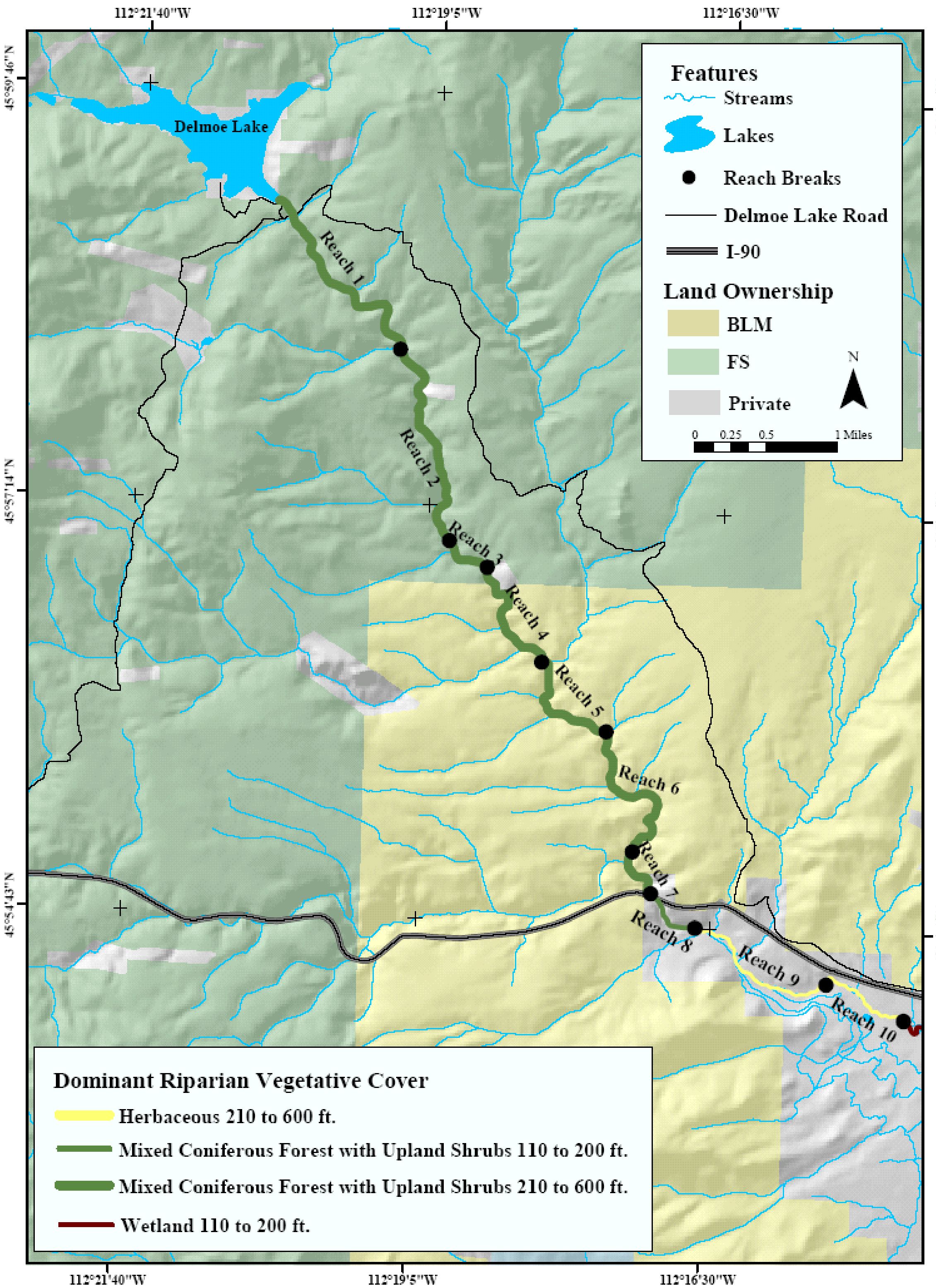

Figure 2-9. Upper Big Pipestone Creek Riparian Vegetation

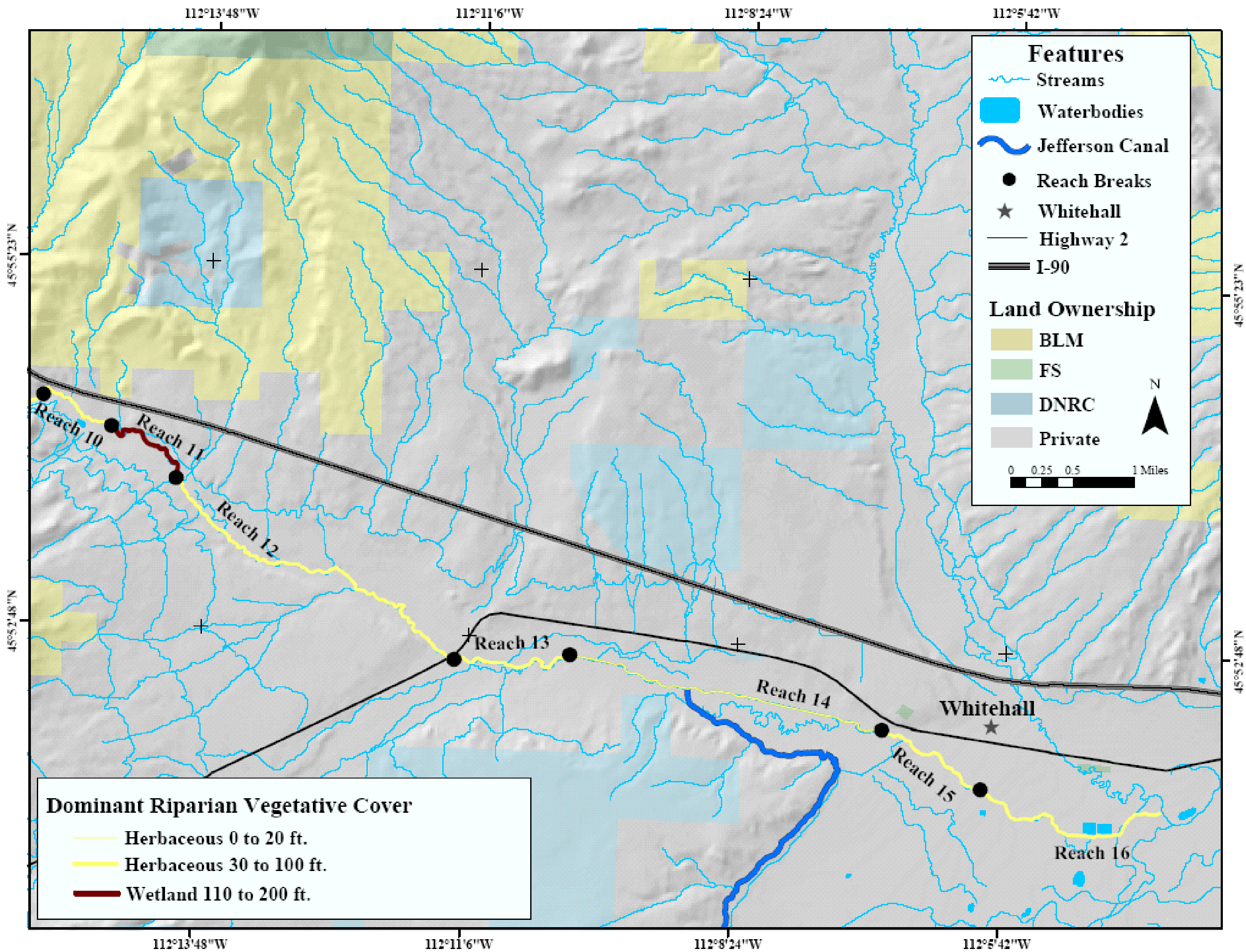

Figure 2-10. Lower Big Pipestone Creek Riparian Vegetation

2.2.1.3 Big Pipestone Creek Pollution Sources

Figure 2-11 displays the pollution sources assigned to the upper reaches of Big Pipestone Creek. Many pollution sources observed along Big Pipestone Creek above Interstate 90 were related to the operation of Delmoe Lake Dam, and unpaved roads and trails. In many instances, the sources of flow alterations from water diversions and impacts from abandoned mine lands were taken from GIS layers which located water rights claims and abandoned mines. The GIS identified sources have generally not been field verified. During the field source assessment, heavy algal growth just below the Delmoe lake outlet, road sediment delivery sites, and channelization from rock walls were observed in Reach 1. In Reach 2, sediment delivery sites from ATV/motorcycle trails, and trash from an old mining operation (wood, metal, tires, furniture) were observed in the stream. The portion of Reach 7 that was surveyed looked fairly healthy, with vigorous riparian vegetation. There were no significant changes in pollution sources between 1983 and 2001.

Figure 2-12 displays the pollution sources assigned to the lower reaches of Big Pipestone Creek. Many pollution sources observed along Big Pipestone Creek below Interstate 90 were related to agricultural operations. During the field source assessment, grazing impacts (trampled banks, overwidened channel, channel braids) were observed in all of the field surveyed reaches, except for Reach 11. Alterations for irrigation diversions were observed in Reaches 11, 13, 14, and 16. In general, stream condition deteriorates in a downstream manner from Reach 10 to Reach 14. For the valley portion of Big Pipestone Creek, only one time period was analyzed so significant changes in pollution sources since 1983 were not determined.

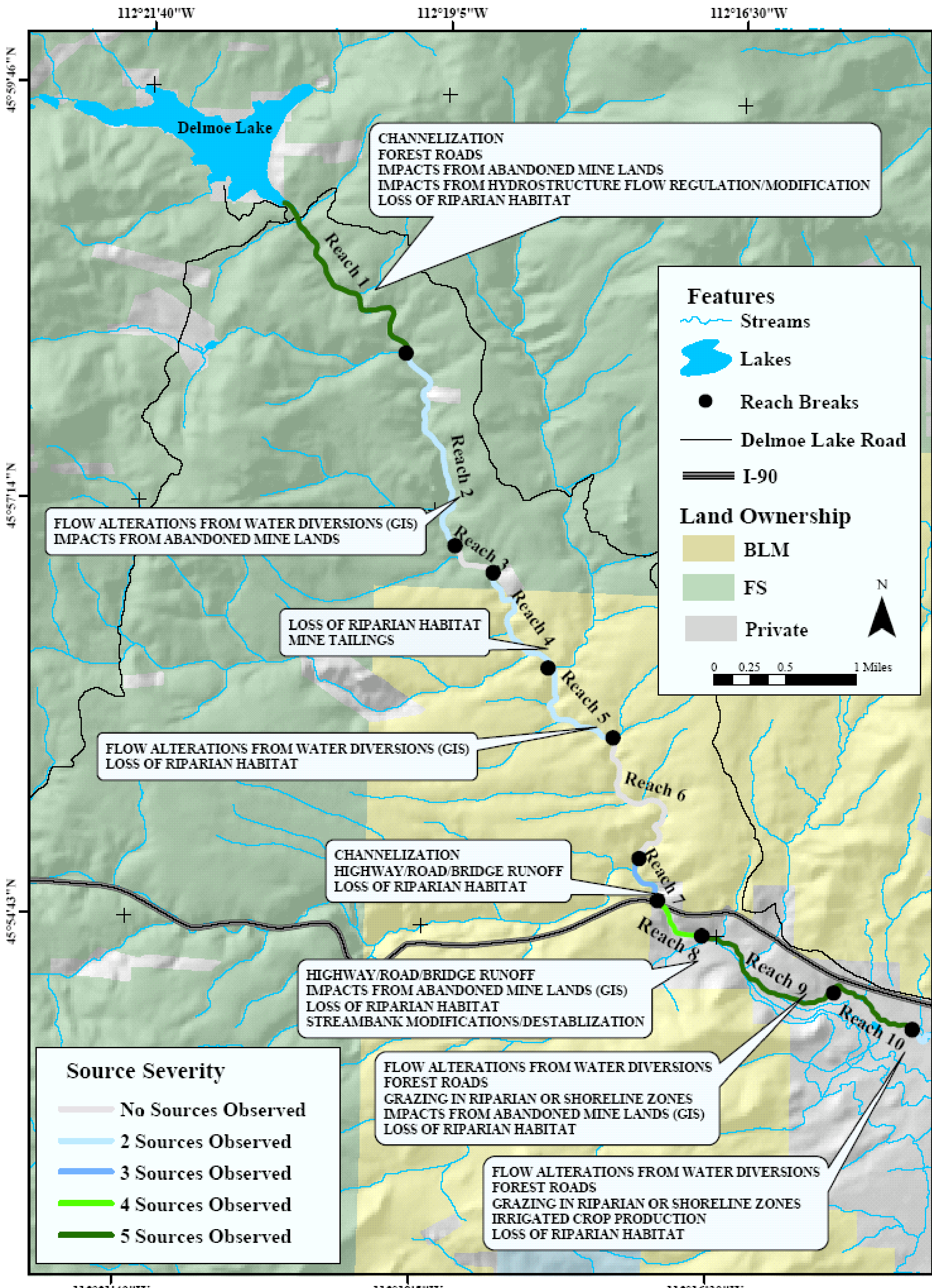

Figure 2-11. Upper Big Pipestone Creek Pollution Sources

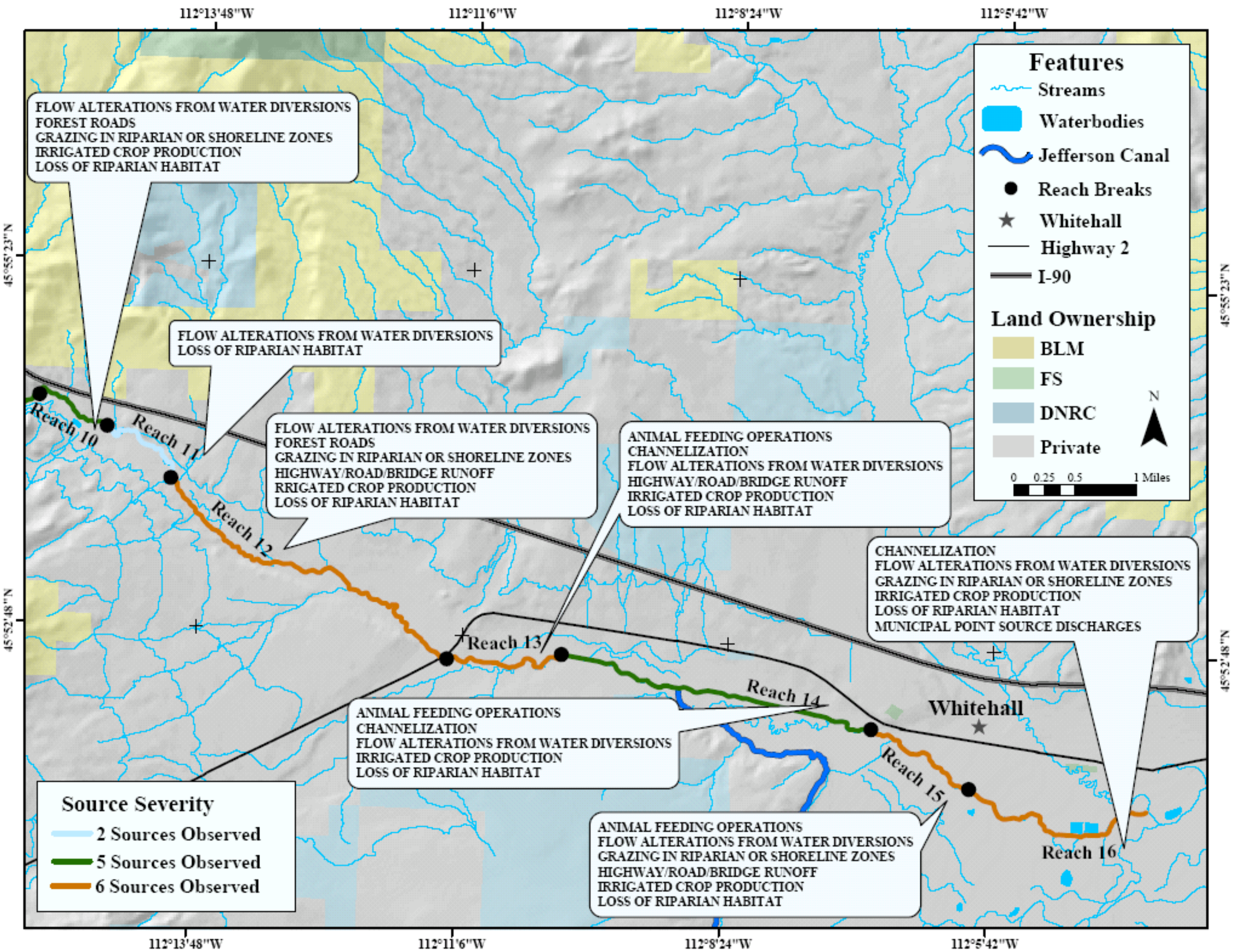

Figure 2-12. Lower Big Pipestone Creek Pollution Sources

2.2.2 Cherry Creek

Cherry Creek headwaters at Little Cherry Creek Spring on the Beaverhead-Deerlodge National Forest. It flows for approximately 7 miles to where it meets the Jefferson River. During the summer irrigation season, landowners report that the stream goes dry on the lower alluvial fan before reaching the Jefferson River. In 1996, the DEQ listed flow alteration as the suspected cause of impairment to Cherry Creek, with agriculture and flow regulation/modification as the suspected pollution sources. According to the 1996 303(d) List, cold water fisheries and associated aquatic life are threatened uses.

For the purposes of the source assessment, Cherry Creek was broken into 6 reaches (**Figures 2-13** to **2-15**). During the 2004 October field source assessment, 3 of the 6 reaches were visited in the field (**Table 2-2**). Stream access on private property was somewhat limited. Where available, field information was incorporated within the results of the source assessment.

Table 2-2. Field Assessment of Cherry Creek Reaches

Cherry Creek Reach Number	Visit Purpose	Percent of Reach Surveyed
Reach 2	Field Survey	40%
Reach 3	Field Survey	10%
Reach 6	Field Survey	10%

2.2.2.1 Cherry Creek Rosgen Stream Types

The channel forms of Cherry Creek are primarily controlled by landform structure (**Figure 2-7**). The prominent landform geology, the Boulder Batholith, has resulted in valley bottom formation along weathered joints. The stream headwaters on relatively steep slopes (A-type) and then progresses downstream to more moderate slopes. The valley bottom is fairly confined (B-type reaches) until exiting the canyon to the alluvial fan (B and Eb reaches). The portion of Reach 2 viewed during the field survey exhibited A, Ea, and G channel types. The Ea section was observed in a steep aspen meadow area, while the stream alternated between G (grazing impacts) and A type sections where the stream was more confined. Reach 3 was surveyed from the confluence of the North Fork of Cherry Creek downstream. Reach 3 exhibited B and Ba-type sections. The portion of Reach 6 viewed in the field exhibited an Eb-type channel. The section of Reach 6 surveyed was below a large irrigation diversion, but diminished flow effects were not observed. According to the property owner, flow is fairly constant; however a landowner further downstream reported that the stream often goes dry during the irrigation season (section not observed). There were no significant changes in channel form between 1983 and 2001.

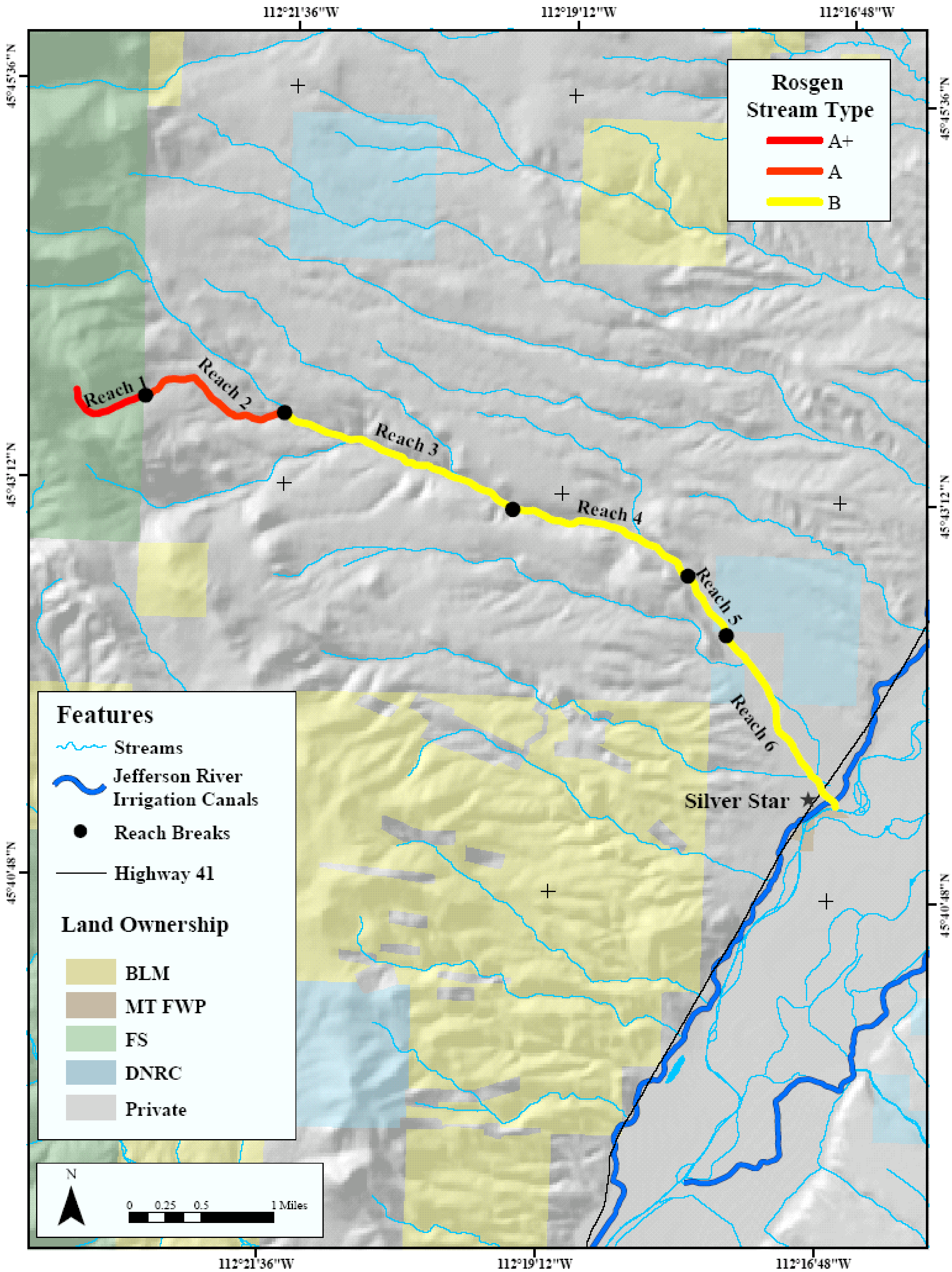

Figure 2-13. Cherry Creek Rosgen Stream Types

2.2.2.2 Cherry Creek Riparian Vegetation

The dominant riparian cover in the headwaters of Cherry Creek was mixed coniferous forest with upland shrubs (**Figure 2-14**). Buffer widths were generally greater than 300 feet wide along both sides of the stream. The buffer widths represented the distance of vegetation surrounding the stream before any disturbance was observed, as opposed to the actual width of 'wet' vegetation (alders, willows, etc.). The relative health category assigned to Reach 1 was: 'Excellent. Vegetation appears to be vigorous, with various age classes present (little or no disturbance).'

The dominant riparian cover along the canyon sections of Cherry Creek was mixed coniferous, dominantly deciduous forest. Buffer widths were generally greater than 60 feet wide along both sides of the stream. The buffer widths represented the distance of vegetation surrounding the stream before any disturbance was observed, or vegetation type changed. Buffer widths were generally limited by valley bottom width, as opposed to unnatural factors. During the field review, willows, apsen, current, alder, and sedges were noted as extending to a maximum of 20 feet from the channel. Some areas of thistle, leafy spurge, and mullein were present. The relative health category assigned to Reaches 2 to 4 was: 'Fair. Vegetation appears healthy, but some disturbance is present.' Between 1983 and 2001, the riparian buffer widths in Reaches 3 and 4 appeared to increase by an average of 40 percent and 25 percent respectively.

The dominant riparian cover along the alluvial fan portion of Cherry Creek was herbaceous, whereby, the grasses or forbs were being grown into the riparian and almost no woody vegetation was present (**Figure 2-14**). The buffer widths of these lower reaches represent the actual width of 'wet' vegetation. Buffer widths were generally less than 50 feet wide along both sides of the stream. The relative health category assigned to Reach 5 was 'Fair'; while the relative health category assigned to Reach 6 was 'Poor' due to notable disturbance. During the field review in Reach 6, cottonwood (regenerating), willows, alder, rose, and sedges were noted as extending generally to a maximum of 20 feet from the channel. Between 1983 and 2001, the riparian buffer width in Reach 6 appeared to increase by an average of 25 percent.

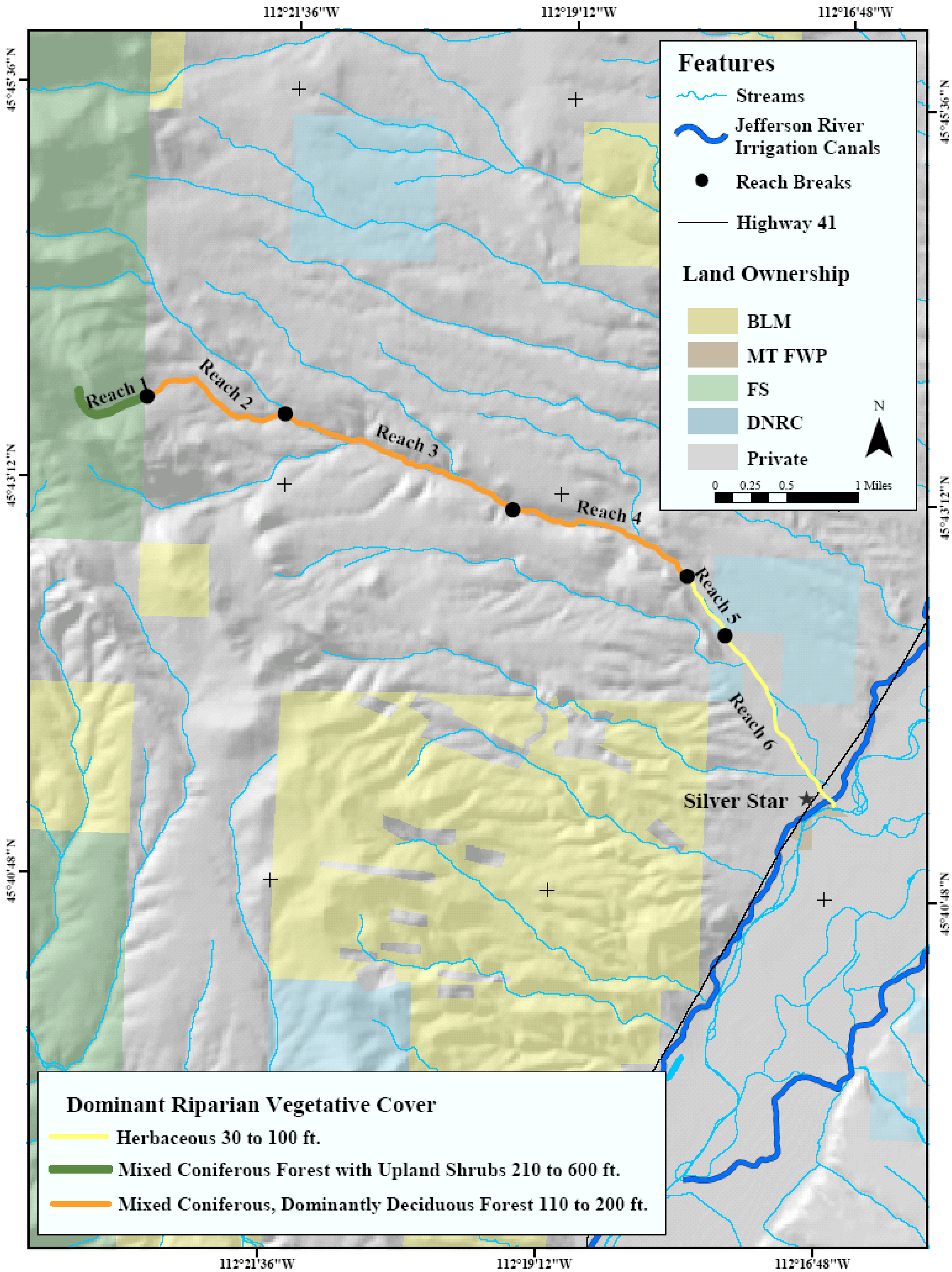

Figure 2-14. Cherry Creek Riparian Vegetation

2.2.2.3 Cherry Creek Pollution Sources

Figure 2-15 displays the pollution sources assigned to Cherry Creek. Many pollution sources observed along Cherry Creek were related to riparian grazing and unpaved roads. In the upper reaches of the creek, the source of flow alterations from water diversions was taken from a GIS layer which located water rights claims. In Reach 6 the impacts from abandoned mine lands was also taken from a GIS layer. The GIS identified sources have not been field verified. Silviculture harvest has occurred upslope from Cherry Creek (south side) and any runoff associated with the harvest would enter in Reaches 2 and 3. Again harmful effects from this impact were not field verified. Grazing impacts observed in the field were more detrimental in Reach 2 than in any of the other reaches observed. Sediment input from unpaved roads was fairly minimal. Loss of riparian habitat was associated with development in the floodplain (roads, crops, housing). There were no significant changes in pollution sources between 1983 and 2001.

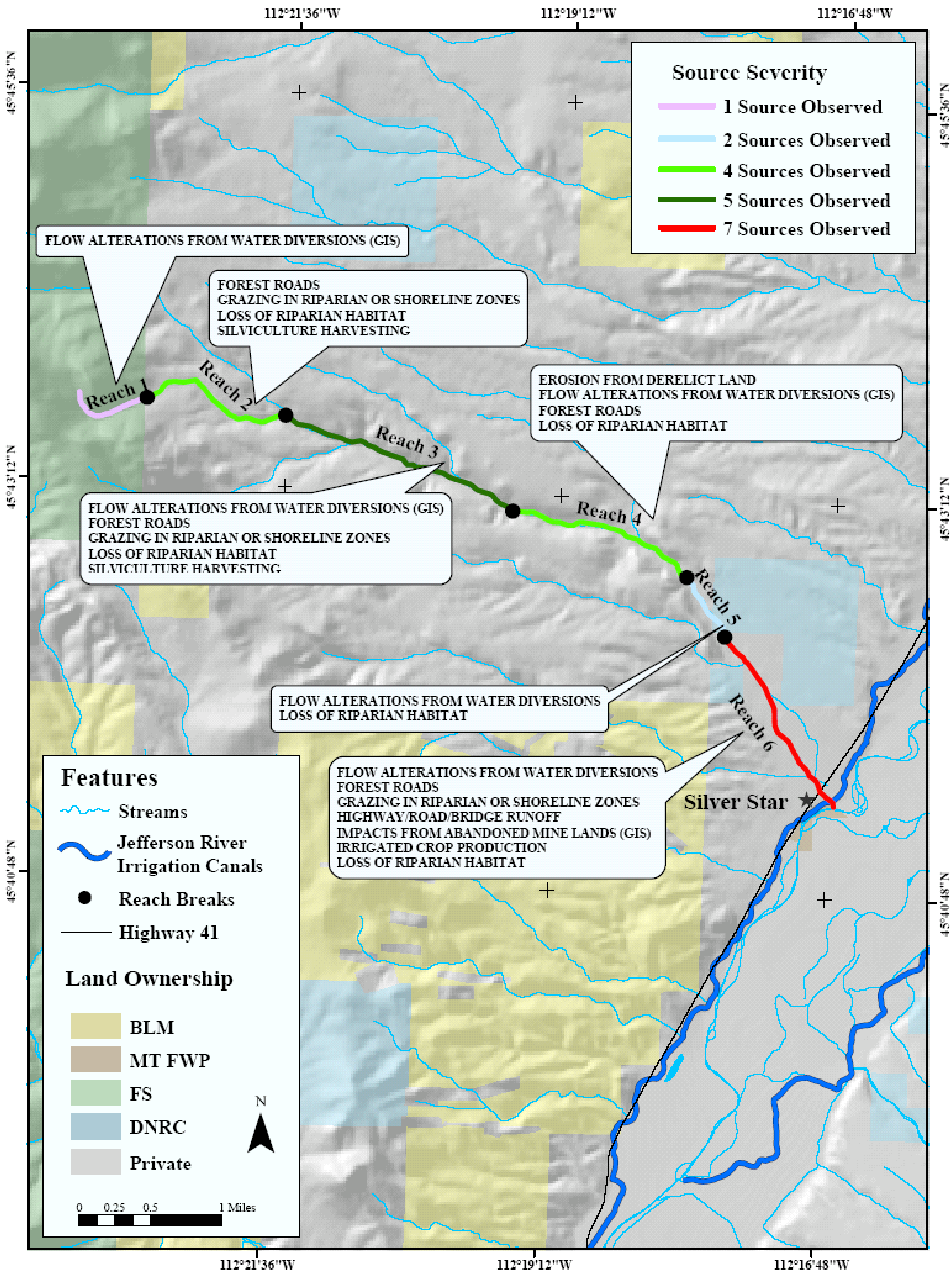

Figure 2-15. Cherry Creek Pollution Sources

2.2.3 Dry Boulder Creek

Dry Boulder Creek forms at the outlet of Boulder Lakes in the Tobacco Root Mountains on the Beaverhead-Deerlodge National Forest. It flows for approximately 11 miles to where it meets the Jefferson River. The stream goes dry for much of the year before it reaches the alluvial fan at the mountain front. In 1996, the DEQ listed flow alteration and siltation as the suspected causes of impairment to Dry Boulder Creek, with agriculture, flow regulation/modification, and resource extraction as the suspected pollution sources. According to the 1996 303(d) List, cold water fisheries and associated aquatic life, drinking water and primary contact recreation are threatened uses.

For the purposes of the source assessment, Dry Boulder Creek was broken into 4 reaches (**Figures 2-16** to **2-18**). During the 2004 October field source assessment, portions of all of the reaches were visited in the field (**Table 2-3**). Where available, field information was incorporated within the results of the source assessment.

Table 2-3. Field Assessment of Dry Boulder Creek Reaches

Dry Boulder Creek Reach Number	Visit Purpose	Percent of Reach Surveyed
Reach 1	Field Survey	10%
Reach 2	Field Survey	70%
Reach 3	Field Survey	10%
Reach 16	Field Survey	Less than10%

2.2.3.1 Dry Boulder Creek Rosgen Stream Types

Figure 2-16 displays the Rosgen channel types assigned to Dry Boulder Creek. The structural controls on the channel forms of Dry Boulder Creek have led to diverse channel types in the headwaters. For this reason, the channel classifications for Reaches 1 and 2 were 'unclassified' after the field review. Channel forms in Reaches 1 and 2 are influenced by past glaciation. In Reach 1, many Rosgen channel types exist. Most likely the channel starts at the mouth of Upper Boulder Lake as an E or C type stream (not observed in field), but then changes type where the stream hits a nickpoint (A-type, observed). At the base of the falls (A), the channel quickly changes to a Ba type, then to an E type, but with multiple channels and areas of braiding where the stream flows into Lower Boulder Lake. Reach 2 is also difficult to type in areas because of the steep gradient, high entrenchment ratio, and braiding. Ea, A, Ba, and E (meadow area) channel types were observed in this reach. The portions of Reaches 3 and 4 observed in the field exhibited B and Ba type channels. After the field review, it was noted that Reach 4 should have probably be broken into at least two reaches on the alluvial fan, possibly around the 5400' contour interval where contour spacing starts to spread further apart (slope and substrate size probably change here). There were no significant changes in channel form between 1983 and 2001.

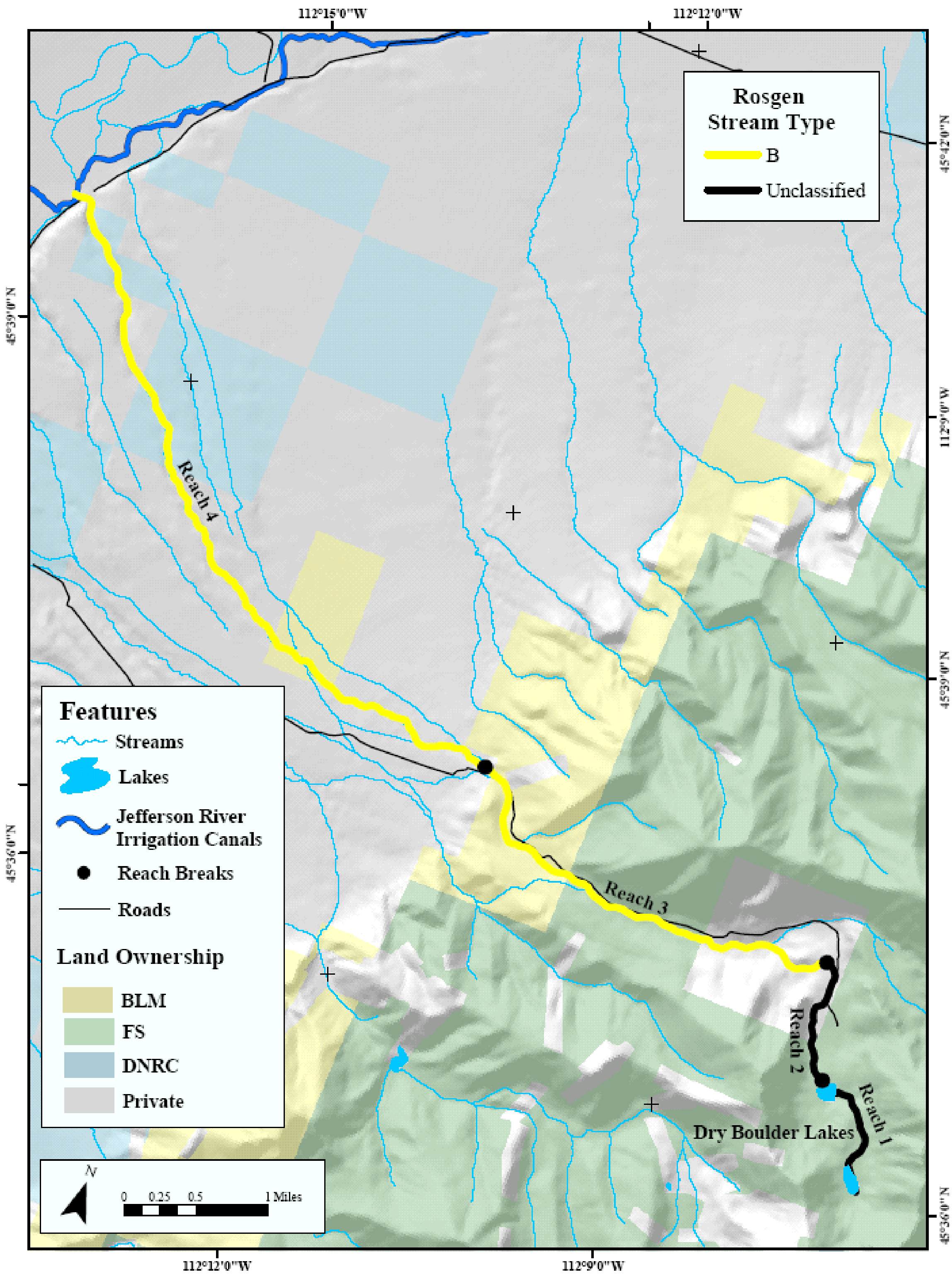

Figure 2-16. Dry Boulder Creek Rosgen Stream Types

2.2.3.2 Dry Boulder Creek Riparian Vegetation

The dominant riparian cover along Dry Boulder Creek was mixed coniferous forest with upland shrubs (**Figure 2-17**). In the headwaters reaches (1 and 2), vegetative width was generally limited by natural factors and could probably be classified as alpine wetland. During the field review, sedges, alpine flowers, and conifers were observed in Reaches 1 and 2. In Reach 3, buffer widths were generally greater than 100 feet wide along both sides of the stream. In Reaches 3 and 4, the riparian vegetation was mostly conifers with some deciduous vegetation growth (cottonwood, chokecherry, maple). Near the mouth, more deciduous vegetation was observed. Along the areas observed in Reach 4, riparian vegetative width was limited by moisture. The relative health category assigned to all of the reaches was: 'Fair. Vegetation appears healthy, but some disturbance is present.' There were no significant changes in riparian vegetation between 1983 and 2001.

2.2.3.3 Dry Boulder Creek Pollution Sources

Figure 2-18 displays the pollution sources assigned to Dry Boulder Creek. Few pollution sources were observed in the field. The most detrimental source observed was a road sediment delivery site near the end of Reach 3. In some instances, the sources of flow alterations from water diversions and impacts from abandoned mine lands were taken from GIS layers which located water rights claims and abandoned mines. The GIS identified sources have generally not been field verified. Some habitat disturbance in the vicinity of an old mine site in Reach 1 was visible on the aerial photos, but this section of the stream was difficult to access and not field observed. Unfortunately, the canal diversion to Coal Creek (Reach 3) was not noted before the field assessment, and thus it could not be determined if this canal takes all of the stream’s flow. It is suspected that the change in lithology from crystalline rocks to porous carbonate rocks in Reach 3 may contribute to natural stream dewatering. On the alluvial fan (Reach 4) the stream goes distributary and probably does not carry flow, except during spring runoff and intense rainfall events (fairly characteristic of streams on alluvial fans in arid environments). There were no significant changes in pollution sources between 1983 and 2001.

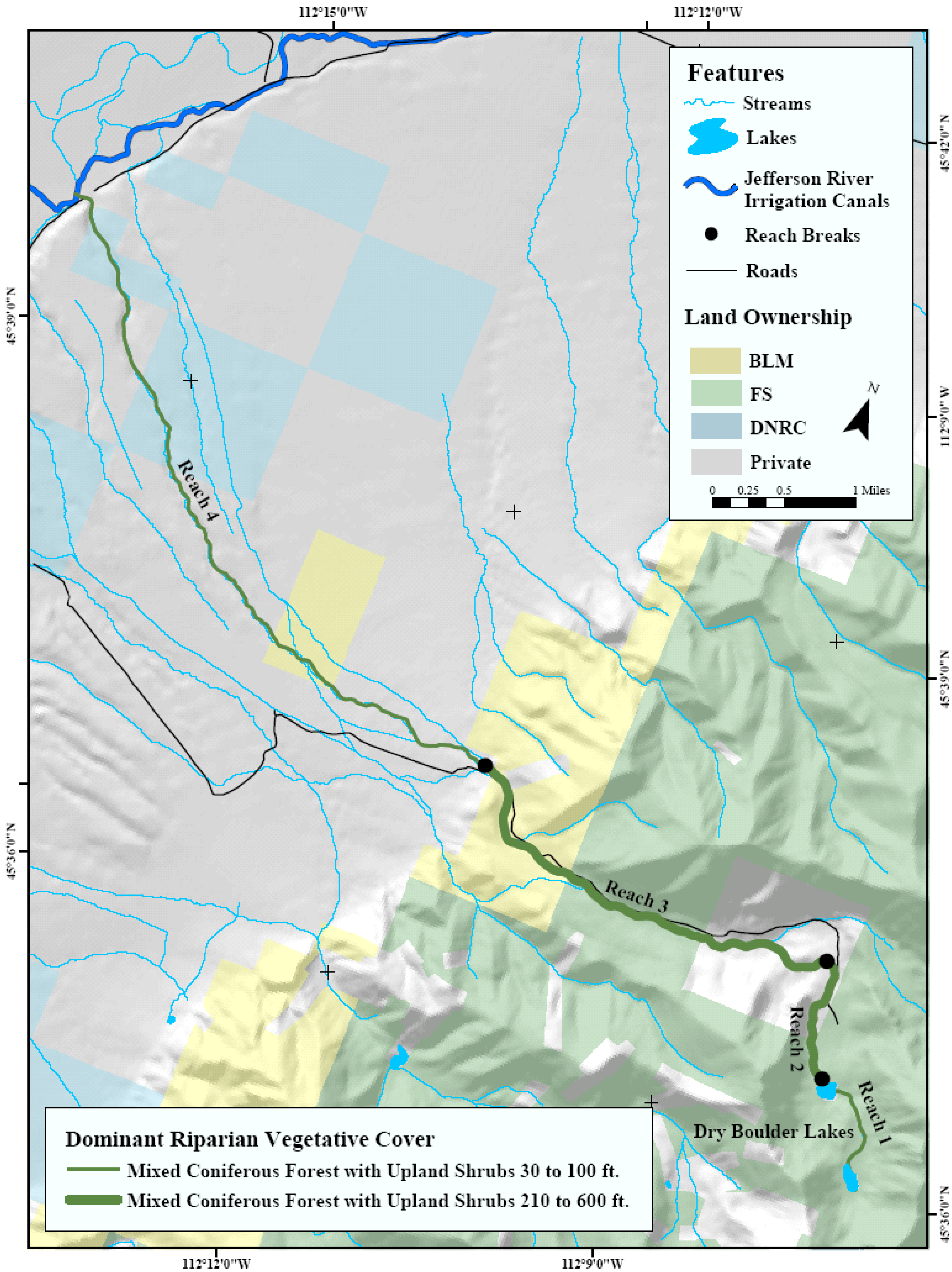

Figure 2-17. Dry Boulder Creek Riparian Vegetation

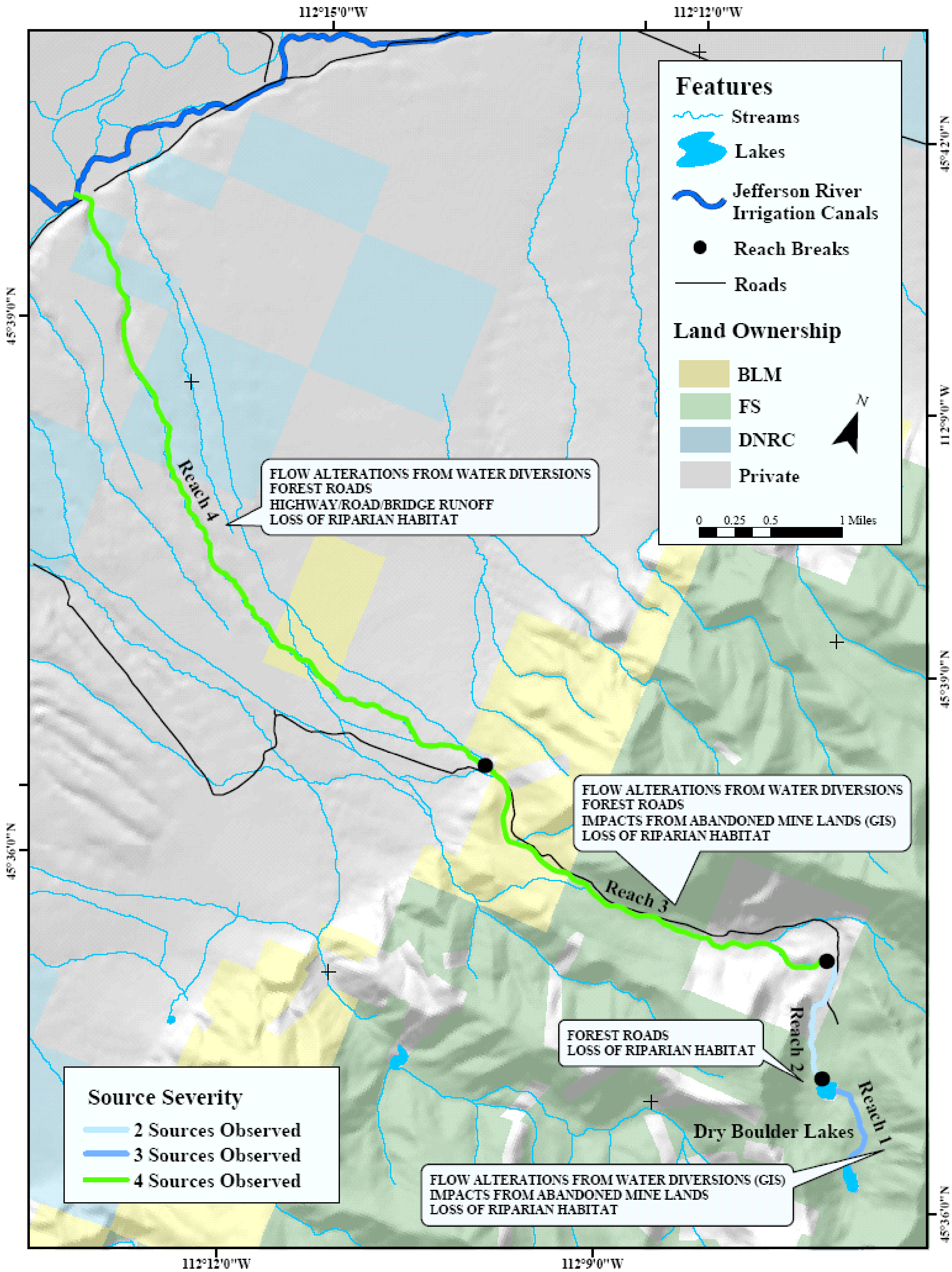

Figure 2-18. Dry Boulder Creek Pollution Sources

2.2.4 Fish Creek

Fish Creek headwaters in the Highland Mountains on the Beaverhead-Deerlodge National Forest. It flows for approximately 20 miles to where it meets the Jefferson Canal, one of the major irrigation canals in the Jefferson Valley. For much of the year the creek goes dry before reaching the Jefferson Canal due to water withdrawals. The suspected causes of impairment to Fish Creek are cadmium, flow alteration, habitat alterations, and siltation. Suspected pollution sources to Fish Creek include abandoned mines, acid mine drainage, agriculture, channelization, flow regulation/modification, and resource extraction. According to the 2004 303(d) List, drinking water supply is an impaired water use; primary contact recreation is a fully supported use, while all other uses have not been assessed.

For the purposes of the source assessment, Fish Creek was broken into 18 reaches (**Figures 2-19** to **2-24**). During the 2004 water quality monitoring project (May to September) and the October field source assessment, 9 of the 18 reaches were visited in the field (**Table 2-4**). Where available, field information was incorporated within the results of the source assessment.

Table 2-4. Field Assessment of Fish Creek Reaches

Fish Creek Reach Number	Visit Purpose	Percent of Reach Surveyed
Reach 2	Field Survey, Water Quality Monitoring	Less than 5%
Reach 3	Field Survey	100%
Reach 4	Field Survey, Water Quality Monitoring	95%
Reach 5	Field Survey, Water Quality Monitoring	Less than 5%
Reach 6	Field Survey	25%
Reach 7	Field Survey	Less than 5%
Reach 8	Field Survey, Water Quality Monitoring	Less than 5%
Reach 14	Field Survey	20%
Reach 15	Water Quality Monitoring	Less than 5%

2.2.4.1 Fish Creek Rosgen Stream Types

The channel forms of Fish Creek within the Highland Mountains are predominantly controlled by landform structure, as well as historical land uses (**Figure 2-19**). The upper reaches have been affected by faulting and glaciation, and more recently by placer mining and logging related activities. The entire length of Reach 3 was surveyed and channel form was found to be variable. The reach begins with transition from a B-type to C-type stream, close to the middle of the reach the stream is channelized and exhibits a G-type channel. There were areas of Reach 3 and Reach 4 that were not classifiable, mostly due to the effects of placer mining. Reach 5 was noted as a good potential for a reference B-type channel. Reach 6 appeared to have been altered by the removal of beaver dams (straightened, incised) and had characteristics of C and Bc type channels. From Reach 7 to 13 (**Figure 2-20**), the Boulder Batholith geology has weathered into

narrow valley bottom sections (B-type reaches), as well as less confined valley bottom areas (C-type reaches). There were no significant changes in channel form between 1983 and 2001.

Many of the channel forms of Fish Creek in the Jefferson Valley are controlled by landform structure, and historical and current landuse activities (**Figure 2-20**). Channel form on the alluvial fan (Reaches 14 to 17) tended to be more unconfined than expected (C-type versus B-type). Portions of Reaches 14 and 15 viewed during the field survey exhibited C-type channels. Reach 17 was typed as a G channel due to the lack of water and vegetation, however this was not field verified. Fish Creek usually goes dry before entering Fish Creek Canal (Reach 18). Reach 18 was not classified due to the fact that it is part of a major irrigation canal system in the Jefferson Valley, and probably carries flow from the Jefferson River versus Fish Creek. For the valley portion of Fish Creek, only one time period was analyzed so significant changes in channel form since 1983 could not be determined.

2.2.4.2 Fish Creek Riparian Vegetation

The dominant riparian cover along Fish Creek within the Highland Mountains was mixed coniferous forest with upland shrubs (**Figure 2-21**). Reach 13 is also within the Highland Mountains (**Figure 2-22**). Buffer widths were generally greater than 100 feet wide along both sides of the stream. The buffer widths represented the distance of vegetation surrounding the stream before any disturbance was observed, as opposed to the actual width of 'wet' vegetation (alders, willows, etc.). Healthy riparian vegetation was virtually absent in Reaches 3 and 4, and could probably be attributed to many sources (grazing, logging, placer mining, and roads). The relative health categories in the upper reaches varied from 'Excellent' to 'Poor' depending on the amount of disturbance visible. In Reach 6, the willows were decadent and dying and a thistle infestation was present. Between 1983 and 2001, the riparian buffer widths in Reach 2 appeared to decrease by an average of 20 percent, but in Reach 10 appeared to increase by an average of 90 percent.

The dominant riparian plants along Fish Creek in the Jefferson Valley were wetland species (**Figure 2-22**). The exception to this was Reach 17, where vegetation was basically absent. The buffer widths of these lower reaches represented the actual width of 'wet' vegetation (alders, willows, etc.). Buffer widths were generally less than 100 feet wide along both sides of the stream. The relative health category assigned to most of the valley reaches was: 'Fair'. During the field review in Reach 14, service berry, alder, rose, red osier, and willows were noted as extending generally to a maximum of 50 feet from the channel. Some areas of knapweed and leafy spurge were observed in Reaches 14 and 15. For the valley portion of Fish Creek, only one time period was analyzed so significant changes in riparian vegetation since 1983 could not be determined.

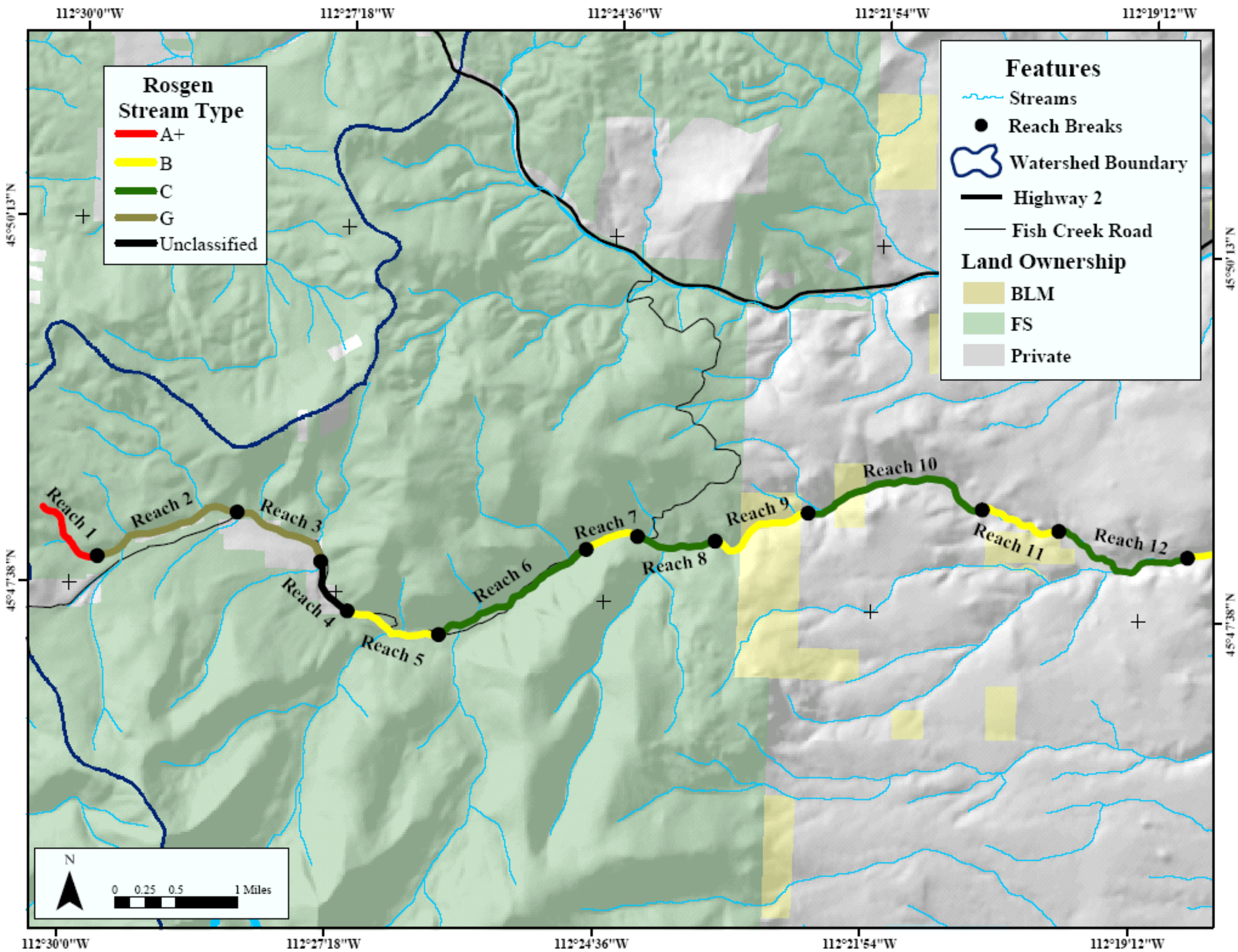

Figure 2-19. Upper Fish Creek Rosgen Stream Types

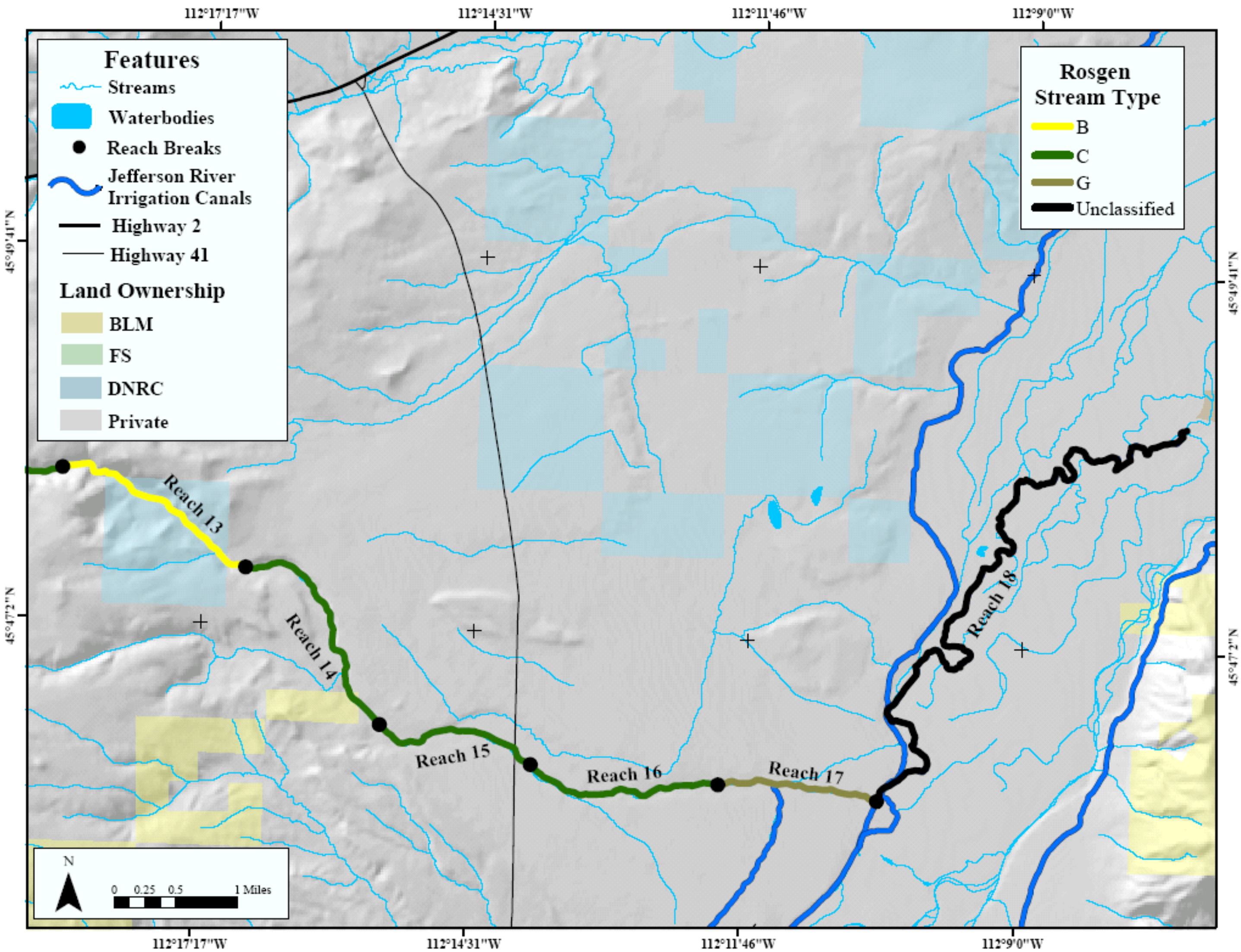

Figure 2-20. Lower Fish Creek Rosgen Stream Types

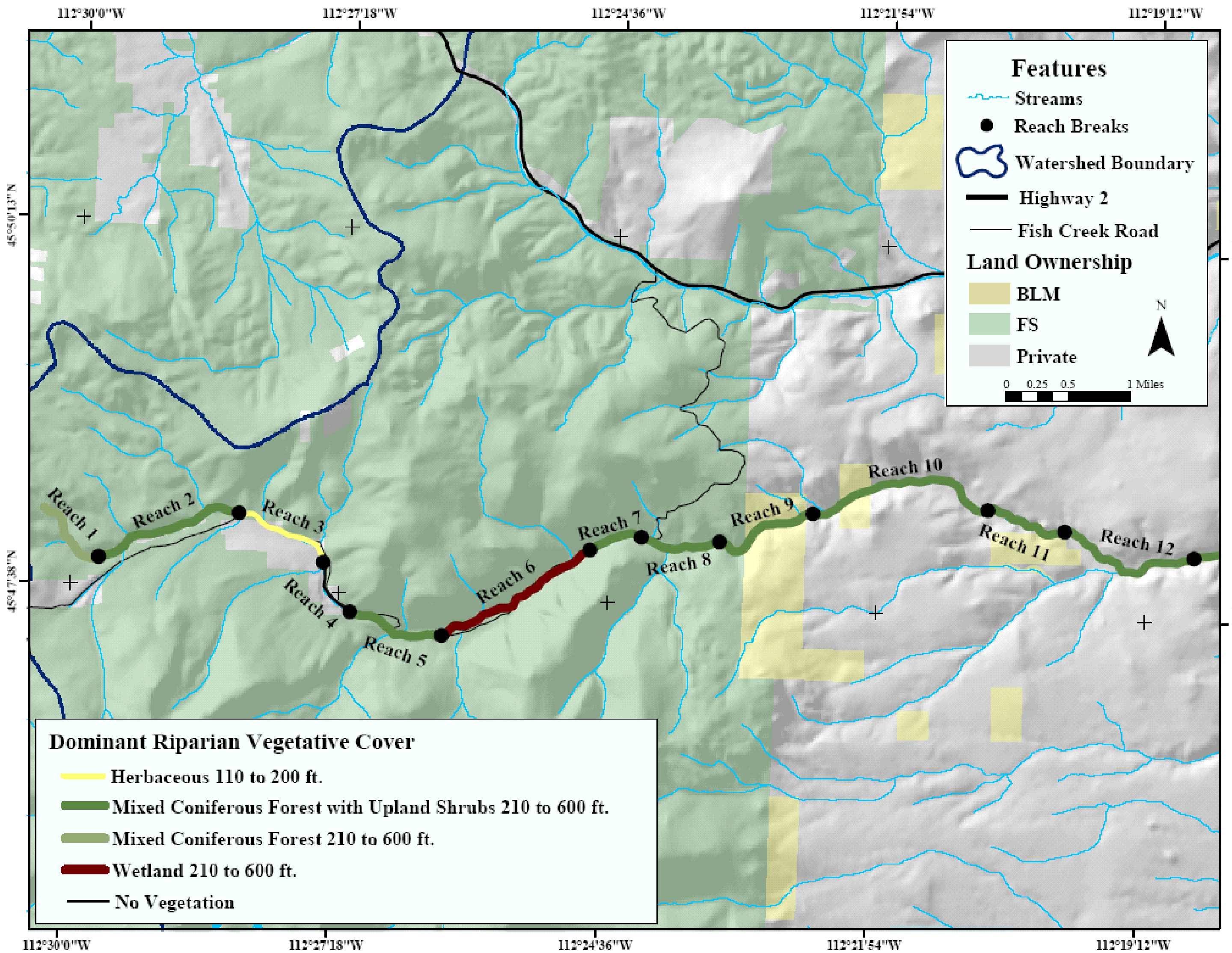

Figure 2-21. Upper Fish Creek Riparian Vegetation

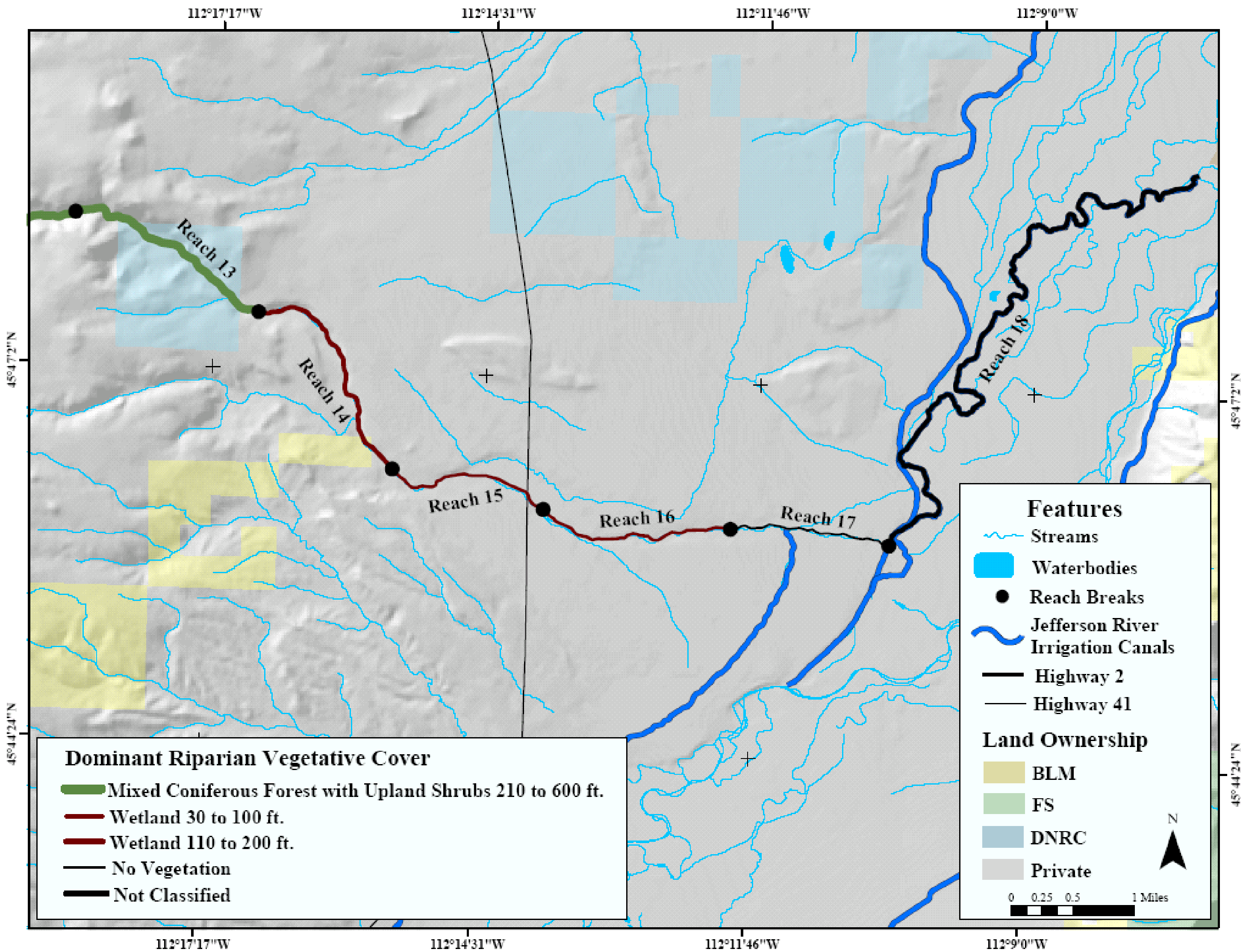

Figure 2-22. Lower Fish Creek Riparian Vegetation

2.2.4.3 Fish Creek Pollution Sources

Figure 2-23 displays the pollution sources assigned to the upper reaches of Fish Creek. Many pollution sources observed along upper Fish Creek were related to placer mining, riparian grazing, and unpaved roads. In many instances, the sources of flow alterations from water diversions and impacts from abandoned mine lands were taken from GIS layers which located water rights claims and abandoned mines. The GIS identified sources have generally not been field verified. Silviculture harvests before 1983 have occurred upslope from and adjacent to Fish Creek. Any runoff associated with the harvests would enter in Reaches 1 through 5. Harmful effects from this impact were not observed in the field. An interesting observation was made during the field survey that the extreme channel modifications in Reach 4, which have lowered the base level for this reach, actually benefit the creek because a lot of the sediment generated in Reach 3 is not able to flow into Reach 4. There were no significant changes in pollution sources between 1983 and 2001.

Figure 2-24 displays the pollution sources assigned to the lower reaches of Fish Creek. Many pollution sources observed on the aerial photographs for lower Fish Creek were related to agricultural operations (irrigation diversions, cropping, and loss of riparian area). During the field source assessment, active beaver dams were observed in Reach 14. The landowner did not eradicate beavers on the property in order to help to maintain flow levels and soil moisture. Discussions with the landowner revealed that dewatering of the creek results in isolation of a genetically pure westslope cutthroat trout population, which apparently thrives in the reaches above the alluvial fan. For the valley portion of Fish Creek, only one time period was analyzed so significant changes in pollution sources since 1983 were not determined.

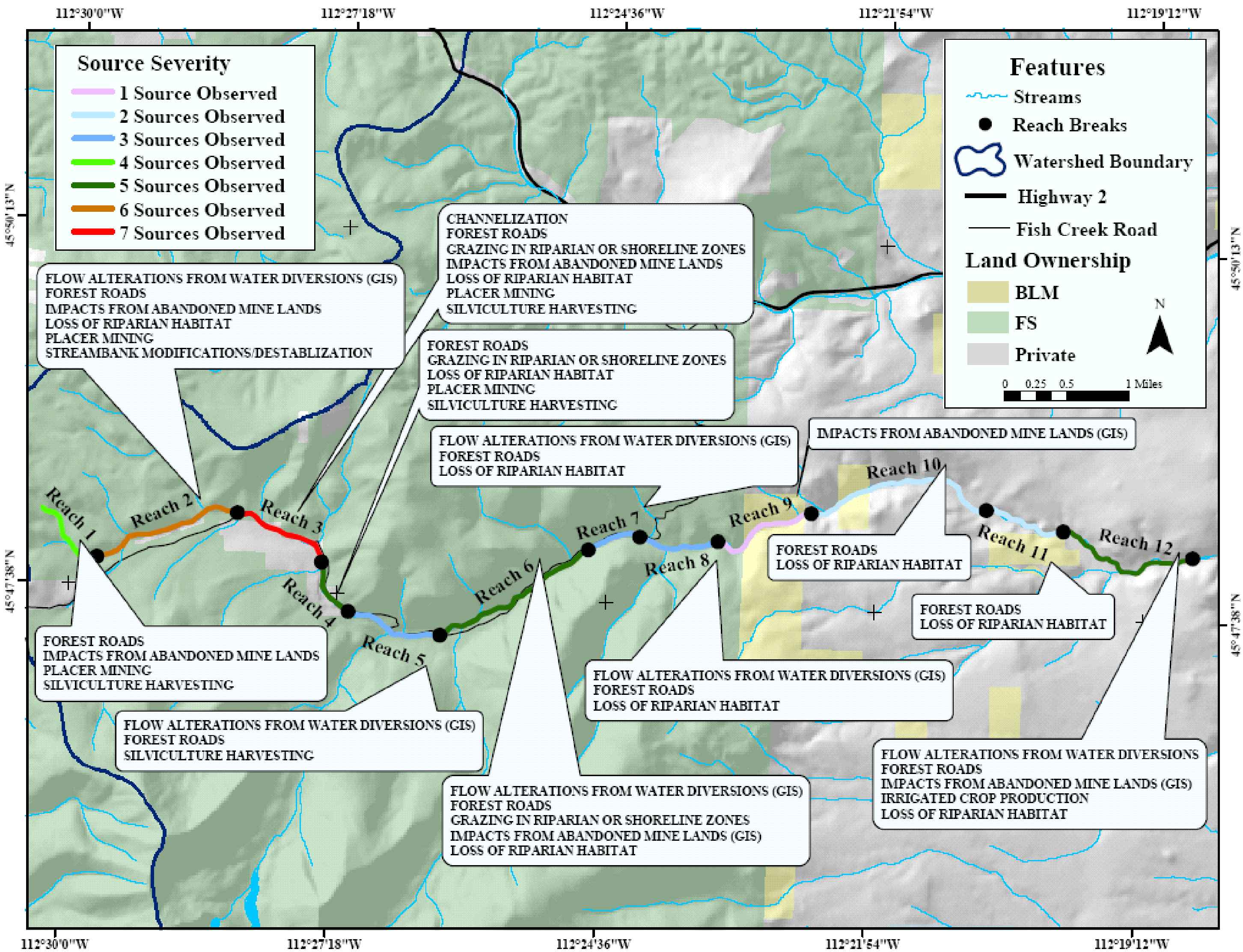

Figure 2-23. Upper Fish Creek Pollution Sources

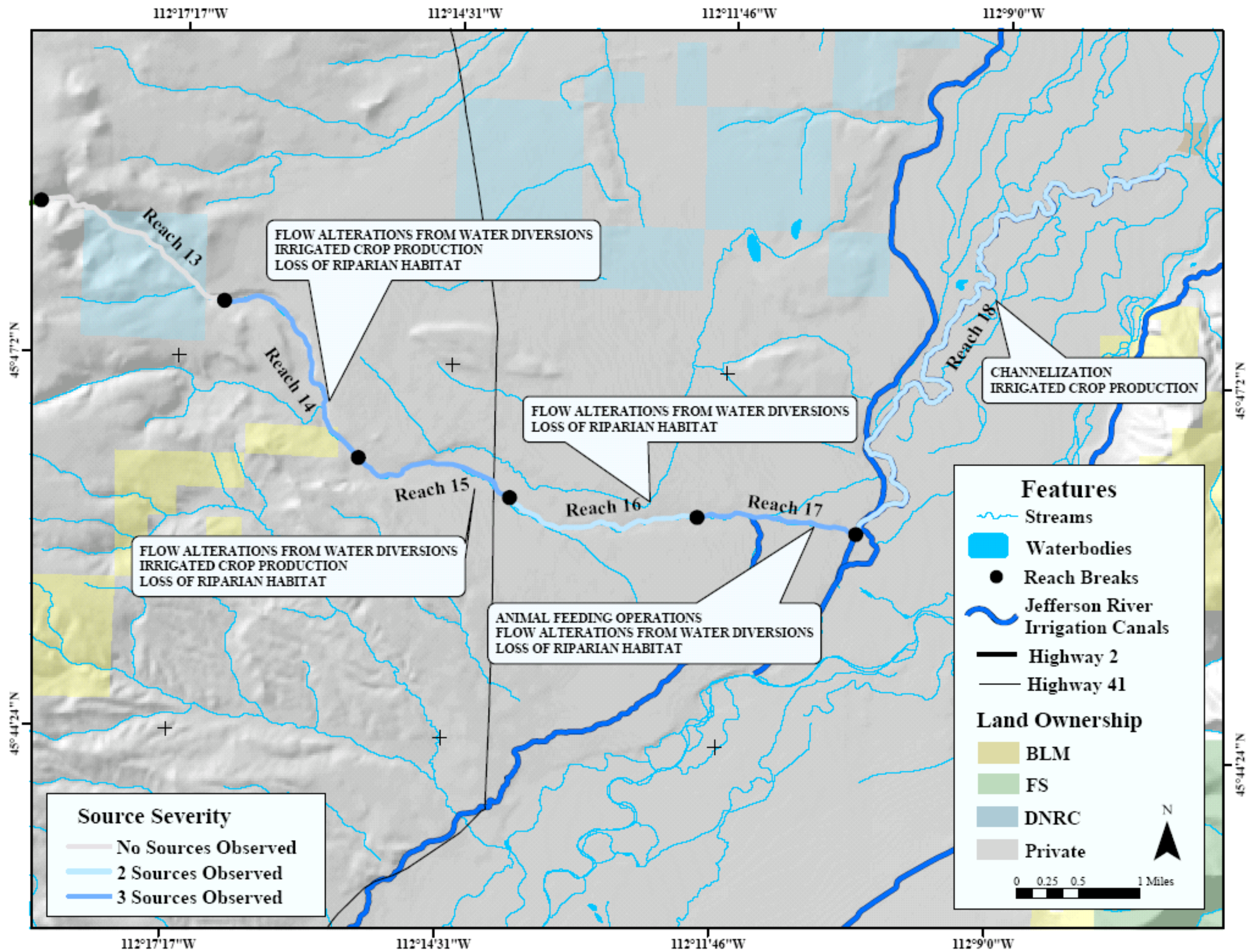

Figure 2-24. Lower Fish Creek Pollution Sources

2.2.5 Fitz Creek

Fitz Creek headwaters in Bull Mountain on the Beaverhead-Deerlodge National Forest. It flows for approximately 5 miles to where it meets Little Whitetail Creek. For much of the year the creek goes dry on the alluvial fan before reaching Little Whitetail Creek. In 1996, the DEQ listed siltation as the suspected cause of impairment to Fitz Creek, with agriculture and road related sources as the suspected pollution sources. According to the 1996 303(d) List, cold water fisheries and associated aquatic life are threatened uses.

For the purposes of the source assessment, Fitz Creek was broken into 6 reaches (**Figures 2-25** to **2-27**). During the 2004 October field source assessment, 2 of the 6 reaches were visited in the field (**Table 2-1**). Stream access on private property was somewhat limited. Where available, field information was incorporated within the results of the source assessment.

Table 2-5. Field Assessment of Fitz Creek Reaches

Fitz Creek Reach Number	Visit Purpose	Percent of Reach Surveyed
Reach 4	Field Survey	Less than 5%
Reach 5	Field Survey	80%

2.2.5.1 Fitz Creek Rosgen Stream Types

The channel forms of Fitz Creek are primarily controlled by landform structure (**Figure 2-25**). The stream headwaters on relatively steep slopes (A-type) and then progresses downstream to more moderate slopes. The valley bottom is fairly confined (B-type reaches) along the canyon and alluvial fan sections, until entering the floodplain of Little Whitetail Creek. The small section of Reach 4 observed in the field appeared to transition from an Eb to B-type channel near the head of the alluvial fan. On the alluvial fan, the stream goes distributary and definition of the main channel was tenuous at best. For this reason, the channel classification for Reach 5 was changed to 'unclassified' after the field review. During the field review, the largest channel walked in, Reach 5 exhibited characteristics of B and mostly G-type channels. Reach 6 was not classified either due to the difficulty of locating the channel on recent photos for this small section of the stream. In 1983, Reaches 3 and 6 were observed as having stream flow. This led to a significant decrease in active channel width between 1983 and 1995.

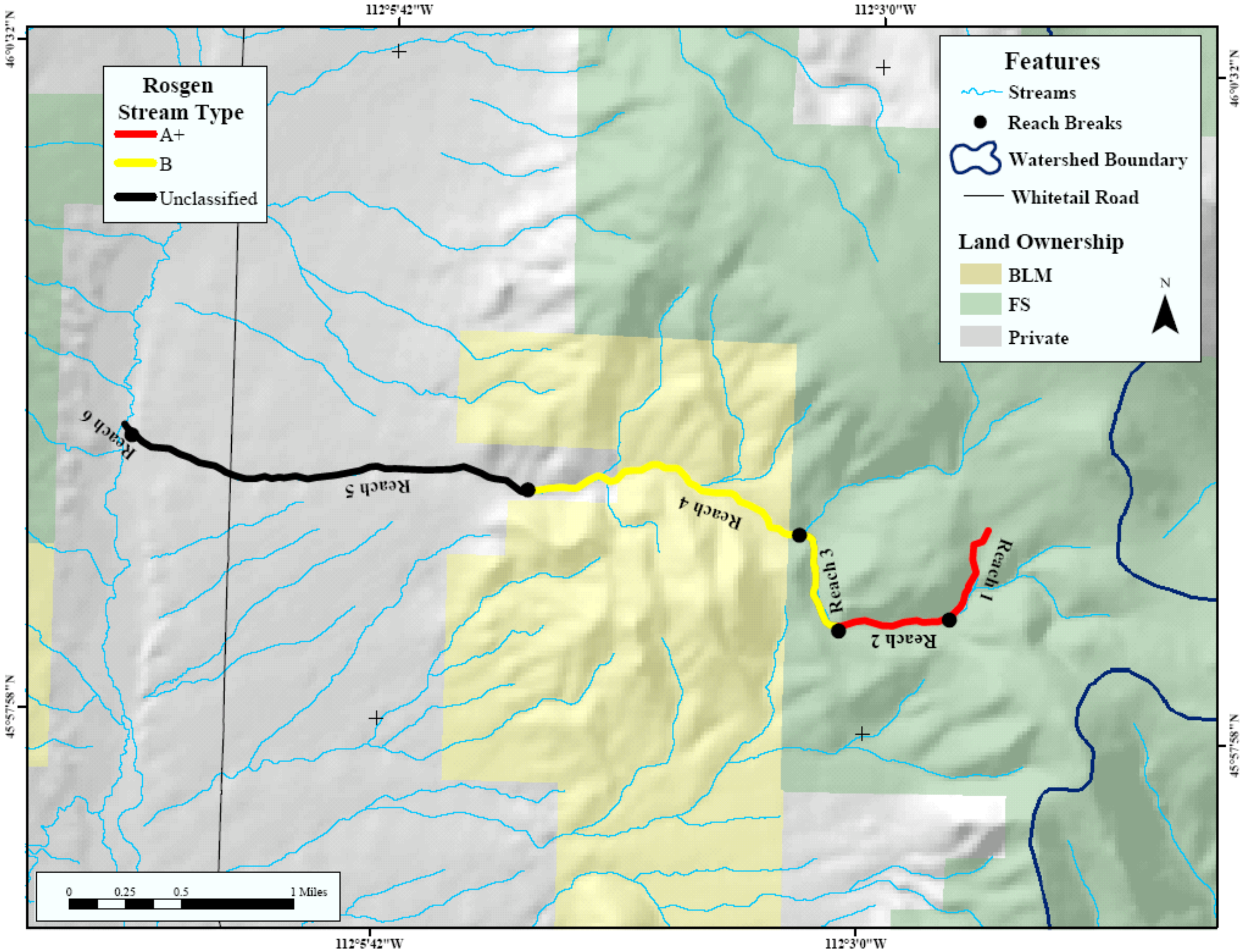

Figure 2-25. Fitz Creek Rosgen Stream Types

2.2.5.2 Fitz Creek Riparian Vegetation

The dominant riparian cover in the headwaters of Fitz Creek was mixed coniferous forest with upland shrubs (**Figure 2-26**). Buffer widths were generally greater than 300 feet wide along both sides of the stream. The buffer widths represented the distance of vegetation surrounding the stream before any disturbance was observed, as opposed to the actual width of 'wet' vegetation (alders, willows, etc.). The relative health category assigned to Reaches 1 and 2 was: 'Fair', due to the presence of an unpaved road.

The dominant riparian cover along Reach 4 was mixed coniferous, dominantly deciduous forest. Buffer width was generally greater than 50 feet wide along both sides of the stream. The buffer widths represented the distance of vegetation surrounding the stream before any disturbance was observed, or vegetation type changed. Buffer widths were generally limited by valley bottom width. During the field review, aspen, rose, sedges, and grasses were observed in the field. The relative health category assigned to Reach 4 was: 'Fair', due to the presence of an unpaved road. Between 1983 and 2001, the riparian buffer width in Reach 4 appeared to increase by an average of 20 percent.

The dominant riparian cover along the Reaches 3, 5, and 6, was herbaceous, whereby, the grasses or forbs were being grown into the riparian and almost no woody vegetation was present (**Figure 2-26**). The buffer widths of these lower reaches represent the actual width of 'wet' vegetation. Buffer widths were generally less than 10 feet wide along both sides of the stream. The relative health category assigned to all of the reaches was 'Fair'. The riparian area in Reach 5 appeared to be limited by moisture. In 1983, Reaches 3 and 6 were observed as having stream flow. This led to a significant decrease in riparian buffer width between 1983 and 1995.

2.2.5.3 Fitz Creek Pollution Sources

Figure 2-27 displays the pollution sources assigned to Fitz Creek. Most of the pollution sources observed on the aerial photos were related to flow alterations and unpaved roads. In many instances, the source of flow alterations from water diversions was taken from a GIS layer, and was not field verified. Grazing was observed along much of Reach 5, but the impacts were fairly minimal due to the lack of water. During the field source assessment the stream was observed as naturally going dry at the head of the alluvial fan. On the alluvial fan (Reach 5) the stream goes distributary and probably does not carry flow, except during spring runoff and intense rainfall events (fairly characteristic of streams on alluvial fans in arid environments). There were no significant changes in pollution sources between 1983 and 2001.

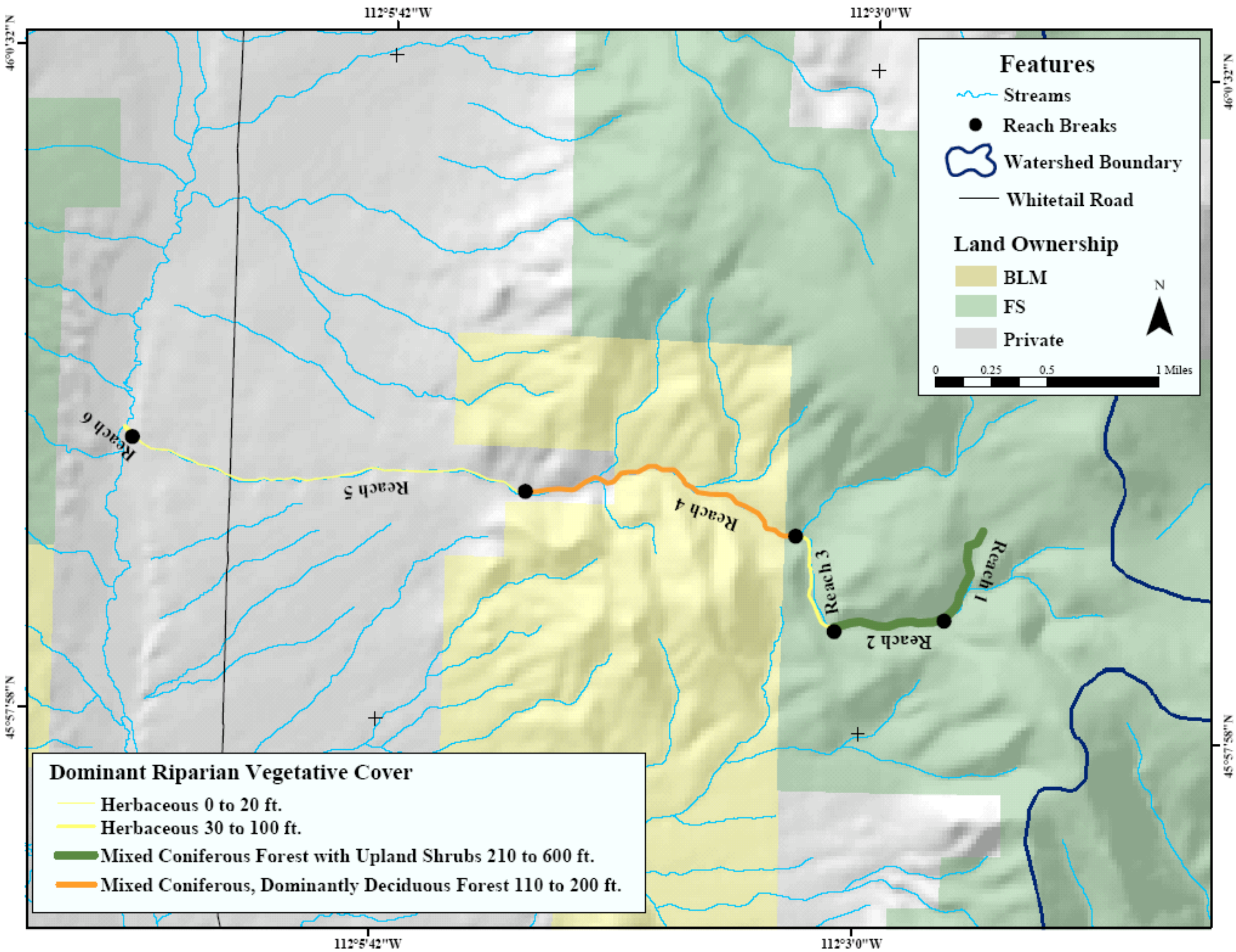

Figure 2-26. Fitz Creek Riparian Vegetation

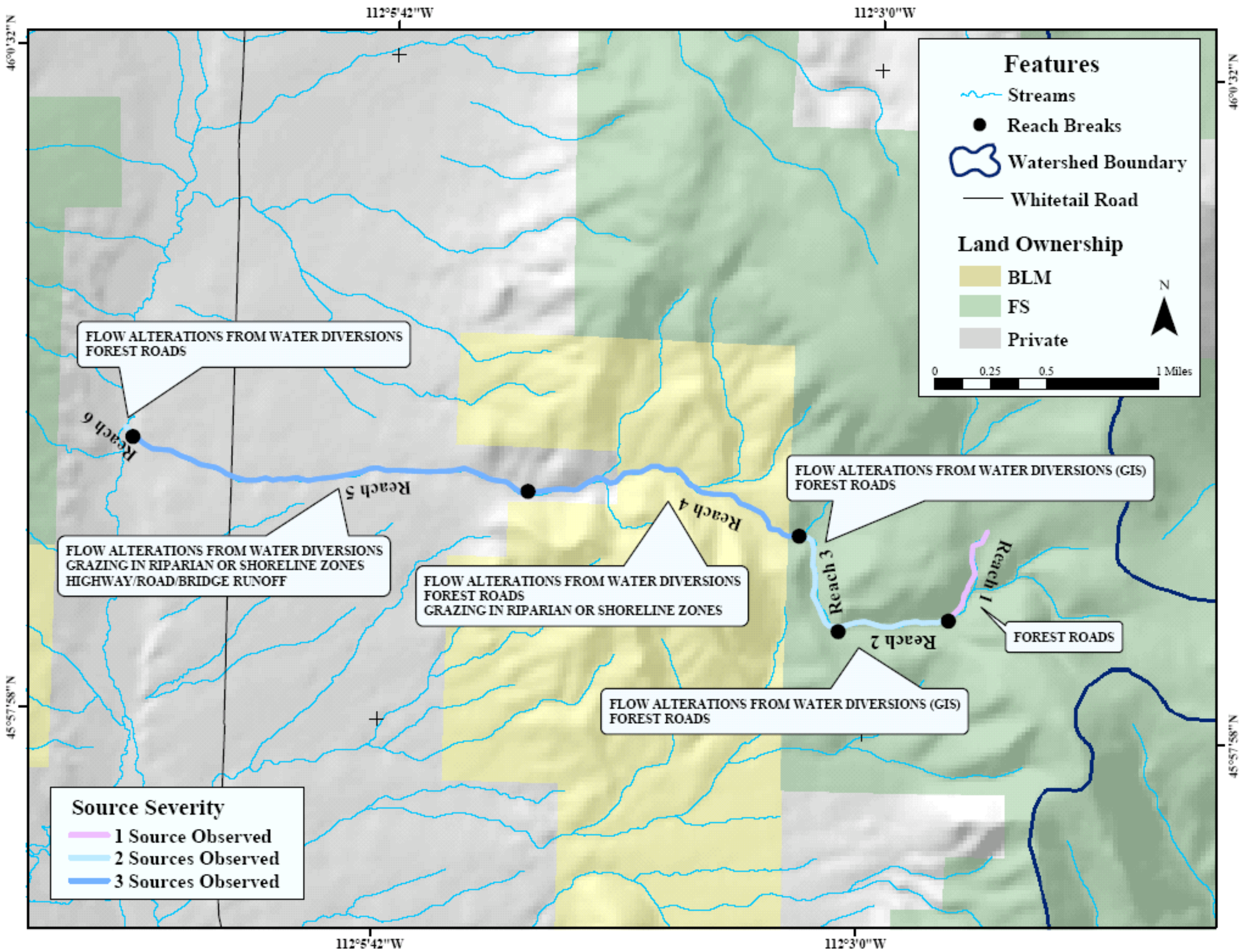

Figure 2-27. Fitz Creek Pollution Sources

2.2.6 Halfway Creek

Halfway Creek headwaters in Halfway Park on the Beaverhead-Deerlodge National Forest. It flows for approximately 8 miles to where it meets Big Pipestone Creek. In 1996, the DEQ listed habitat alterations and siltation as the suspected causes of impairment to Halfway Creek, with agriculture related sources as the suspected pollution sources. According to the 1996 303(d) List, cold water fisheries and associated aquatic life are threatened uses.

For the purposes of the source assessment, Halfway Creek was broken into 7 reaches (**Figures 2-28** to **2-30**). During the 2004 October field source assessment, 2 of the 7 reaches were visited in the field (**Table 2-6**). Stream access was somewhat limited due to impassable roads. Where available, field information was incorporated within the results of the source assessment.

Table 2-6. Field Assessment of Halfway Creek Reaches

Halfway Creek Reach Number	Visit Purpose	Percent of Reach Surveyed
Reach 6	Field Survey	15%
Reach 7	Field Survey	15%

2.2.6.1 Halfway Creek Rosgen Stream Types

The channel forms of Halfway Creek are predominantly controlled by landform structure (**Figure 2-28**). Halfway Park, the headwater area, is a broad wetland meadow with fairly gentle slopes. Channel form here is thought to be an E-type channel. Reach 2 was broken into a separate reach due to an unknown disturbance, which has resulted in a widening of the channel and ponding at the end of the reach. Once the stream leaves Halfway Park, gradient steepens (A-type) and flow is confined to the canyon. From Reaches 4 to 7 the Boulder Batholith geology has weathered into less confined valley bottom sections (Ea and Eb-type reaches), as well as narrow valley bottom areas (B-type reaches). A portion of Reach 6 viewed during the field survey exhibited a B-type channel, with some sections trending toward Eb form. The portion of Reach 7 viewed in the field exhibited a slightly incised, B-type channel. There were no significant changes in channel form between 1983 and 2001.

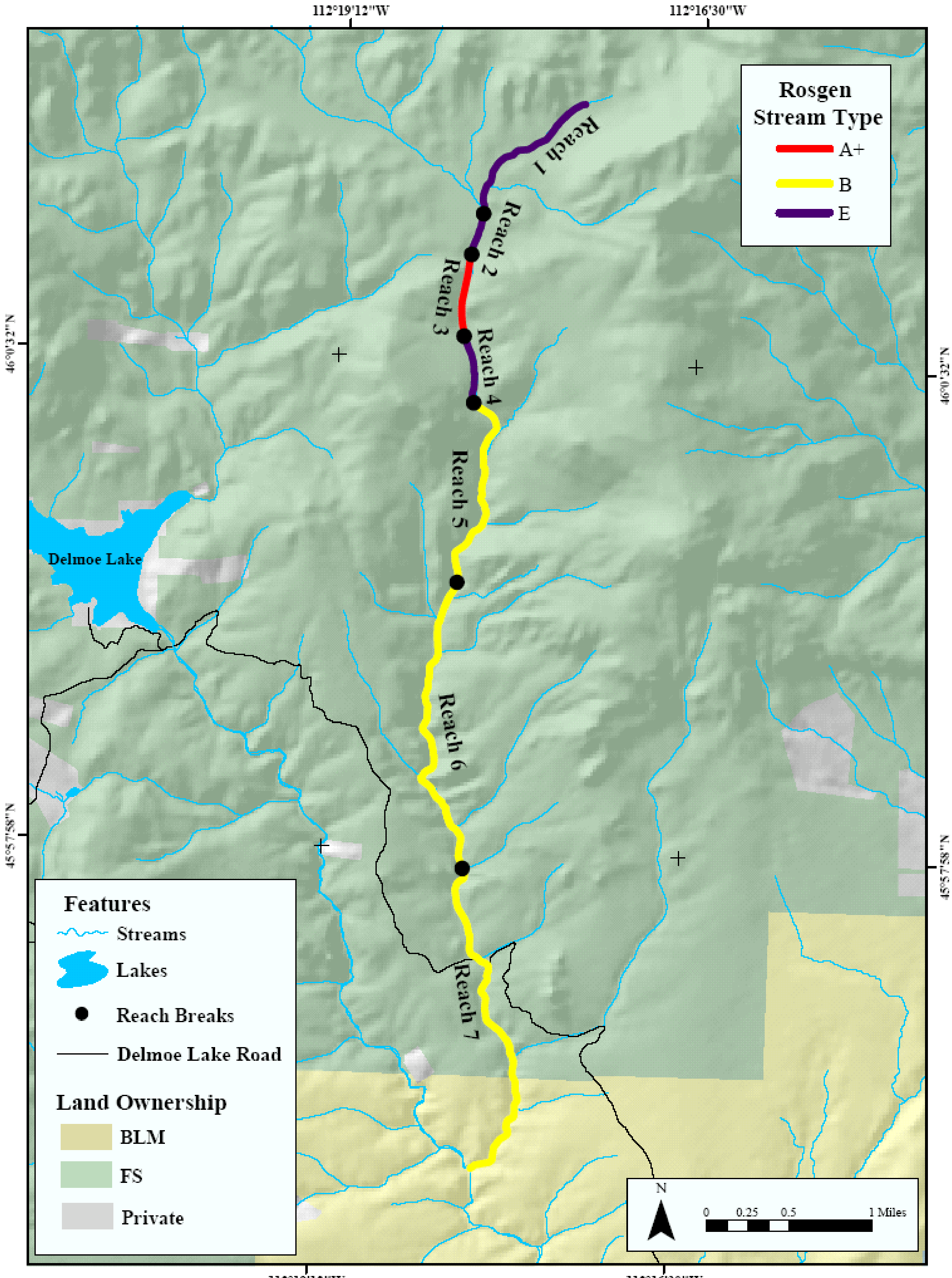

Figure 2-28. Halfway Creek Rosgen Stream Types

2.2.6.2 Halfway Creek Riparian Vegetation

The dominant riparian cover along Halfway Creek in the headwaters was wetland, while the canyon sections were predominantly mixed coniferous forest with upland shrubs (**Figure 2-29**). The headwater wetland buffer widths were generally greater than 100 feet wide along both sides of the stream. The wetland buffer widths represented the distance of vegetation surrounding the stream before any disturbance was observed, and included some area of mixed coniferous forest with upland shrubs. The relative health category assigned to the wetland dominated reaches was 'Fair', due to disturbance from unpaved roads. Mixed coniferous forest buffer widths were generally greater than 200 feet wide along both sides of the stream. GIS layers indicated that no roads exist from Reaches 3 to 5. During the field observation of Reaches 6 and 7, unpaved ATV/motorcycle trails were observed less than 100 feet from the stream, but often were not visible on the aerial photos. During the field review, alder, willows, red osier, rose, current, sedges, and grasses were noted as extending to a maximum of 40 feet from the channel within the conifer forest. The relative health category assigned to the mixed coniferous forest dominated reaches was 'Excellent' in Reaches 3 to 6, but 'Fair' in Reach 7 due to disturbance from unpaved roads. Some areas of thistle and mullein infestation were present. Between 1983 and 2001, the riparian buffer widths in Reaches 6 and 7 appeared to increase by an average of 30 percent and 15 percent respectively.

2.2.6.3 Halfway Creek Pollution Sources

Figure 2-30 displays the pollution sources assigned to Halfway Creek. The sources of flow alterations from water diversions and impacts from abandoned mine lands were taken from GIS layers which located water rights claims and abandoned mines. The GIS identified sources have not been field verified. Loss of riparian habitat was associated with road development and grazing. Many pollution sources observed along Halfway Creek were related to riparian grazing and unpaved roads and trails (overwidened channel, bank erosion, loss of vegetation). During the field source assessment, channel condition appeared to degrade in a downstream manner. There were no significant changes in pollution sources between 1983 and 2001.

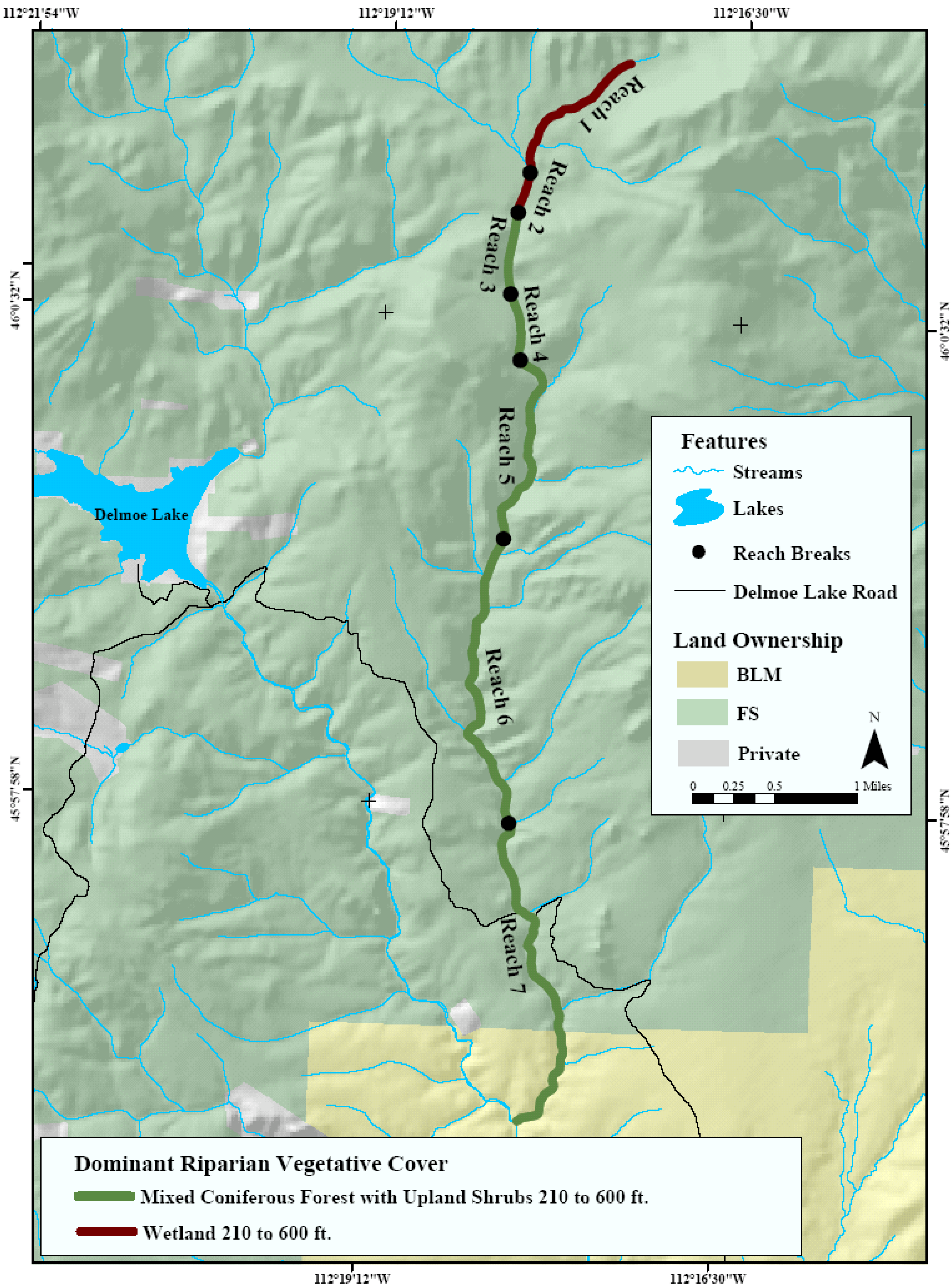

Figure 2-29. Halfway Creek Riparian Vegetation

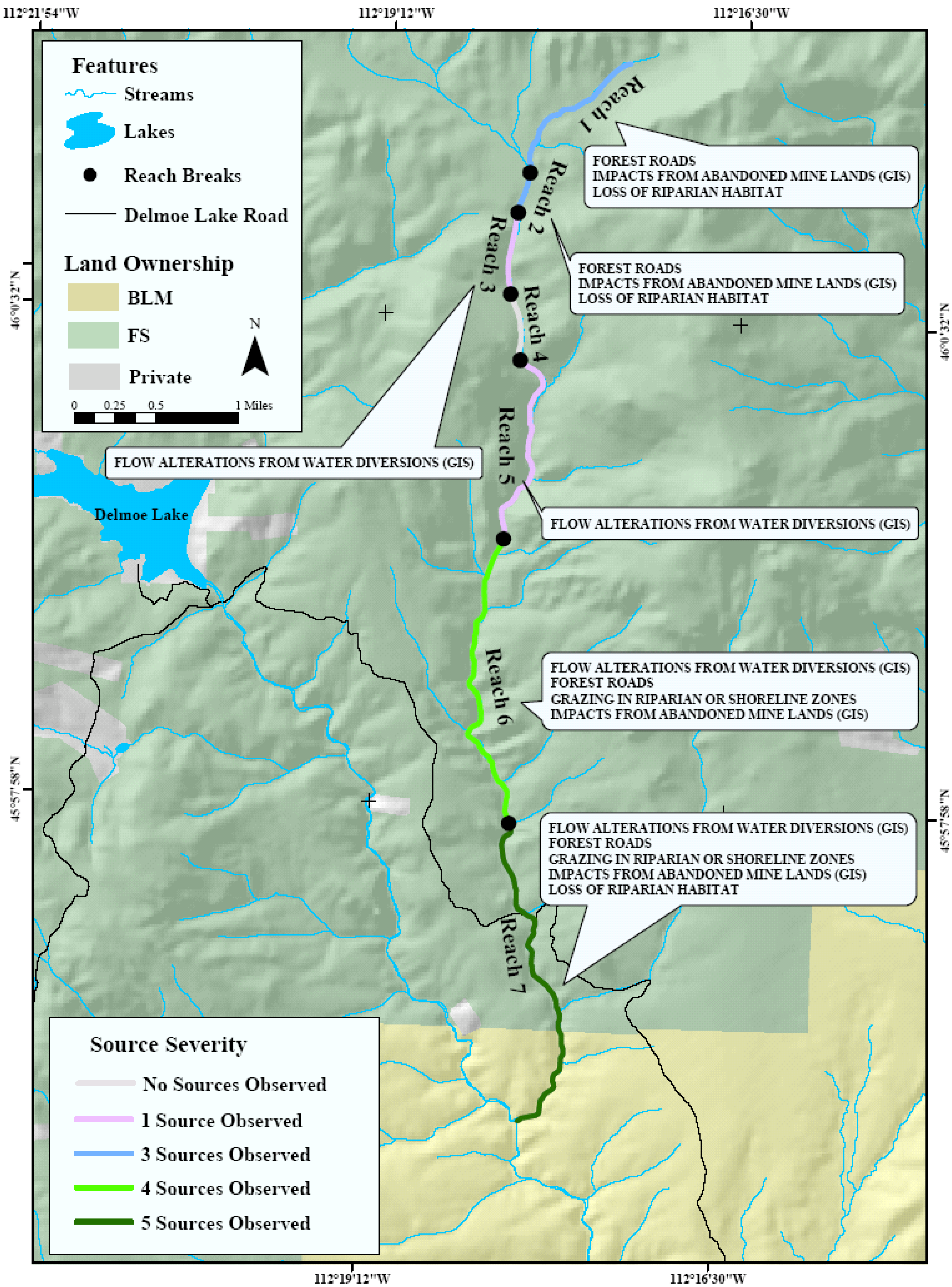

Figure 2-30. Halfway Creek Pollution Sources

2.2.7 Hells Canyon Creek

Hells Canyon Creek headwaters in the Highland Mountains on the Beaverhead-Deerlodge National Forest. It flows for approximately 13 miles to where it meets the Jefferson River. The suspected causes of impairment to Hells Canyon Creek are dewatering/flow alteration, habitat alterations, and siltation. Suspected pollution sources to Hells Canyon Creek include agriculture, grazing related sources, hydromodification, road related sources, and silviculture. According to the 2004 303(d) List, cold water fisheries and associated aquatic life, and primary contact recreation are partially supported uses.

For the purposes of the source assessment, Hells Canyon Creek was broken into 9 reaches (**Figures 2-31** to **2-33**). During the 2004 October field source assessment, 5 of the 9 reaches were visited in the field (**Table 2-7**). Where available, field information was incorporated within the results of the source assessment.

Table 2-7. Field Assessment of Hells Canyon Creek Reaches

Hells Canyon Creek Reach Number	Visit Purpose	Percent of Reach Surveyed
Reach 3	Field Survey	Less than 5%
Reach 4	Field Survey	45%
Reach 5	Field Survey	30%
Reach 6	Field Survey	40%
Reach 9	Field Survey	45%

2.2.7.1 Hells Canyon Creek Rosgen Stream Types

The channel forms of Hells Canyon Creek are predominantly controlled by landform structure, as well as historic and current land uses (**Figure 2-31**). The prominent landform geology, the Boulder Batholith, has resulted in valley bottom formation along weathered joints. The stream headwaters on steep slopes (A-type) and then progresses downstream to more moderate slopes. The canyon valley bottom alternates between confined (B-type) and unconfined sections (C-type). In Reach 9, the stream is also fairly confined within the alluvial fan until reaching the floodplain of the Jefferson River. The portion of Reach 4 viewed during the field survey exhibited C and Bc channel types. Reach 5 exhibited a B-type channel. The portion of Reach 6 viewed in the field exhibited C, Bc, and B-type channel sections. Remnants of beaver dams were observed in Reach 4 and Reach 6. It is suspected that the removal of beaver dams has altered channel form (straightened, incised), and that channel type would probably have naturally trended towards an E-type stream in these reaches. The section of Reach 9 surveyed exhibited a somewhat incised B-type channel on the alluvial fan but was unconfined at the mouth. There was one significant difference in channel measurements between 1983 and 2001. For the 1983 analysis a series of ponds were visible in Reach 2, but in 2001 no ponds were visible.

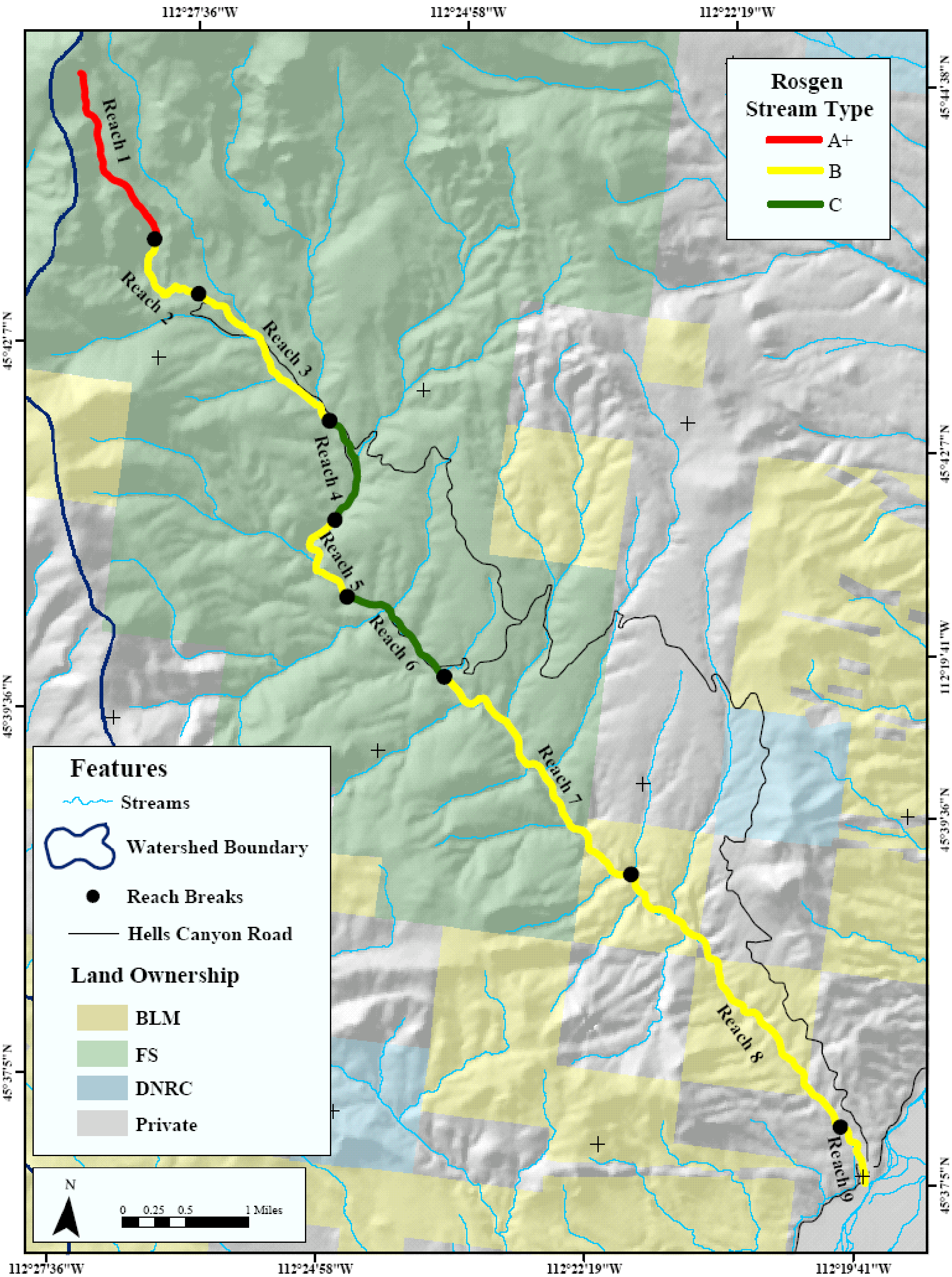

Figure 2-31. Hells Canyon Creek Rosgen Stream Types

2.2.7.2 Hells Canyon Creek Riparian Vegetation

The dominant riparian cover along Hells Canyon Creek in Reaches 1 to 6 alternated between mixed coniferous forest with upland shrubs (confined valley bottom areas) and wetland (less confined valley bottom areas) (**Figure 2-32**). Buffer widths were generally greater than 100 feet wide along both sides of the stream. The buffer widths represented the distance of vegetation surrounding the stream before any disturbance was observed. The relative health category assigned to Reach 1 was ‘Excellent’, while the relative health category assigned to Reaches 2, 3, 4, and 6 was ‘Fair’ due to road disturbance. Reach 5 received a rating of ‘Poor’ in 2001 due to notable areas of bare ground associated with a road failure that occurred sometime after 1983. During the field review in Reach 4, willows, alders, sedges, and grasses were noted as extending to a maximum of 150 feet from the channel in the Hell’s Canyon Creek Riparian Project area (fenced off from grazing). There was a significant difference in vegetative health outside of the riparian project area. Between 1983 and 2001, the coniferous buffer width in Reach 3 appeared to increase by an average of 45 percent; however, in Reach 5 buffer width appeared to decrease by 60 percent (associated with road failure). Between 1983 and 2001, the wetland buffer widths in Reaches 2, 4 and 6 appeared to increase by an average of 15 percent, 40 percent and 35 percent respectively.

The dominant riparian cover along the lower canyon sections of Hells Canyon Creek was mixed deciduous, dominantly coniferous forest (**Figure 2-32**). Buffer widths were generally greater than 100 feet wide along both sides of the stream. The buffer widths represented the distance of vegetation surrounding the stream before vegetation type changed. Buffer widths appeared to be limited by valley bottom width. The relative health category assigned to Reach 7 was ‘Excellent’, while Reach 8 was assigned 'Fair' due to suspected disturbance from unpaved roads.

The dominant riparian cover along the alluvial fan (Reach 9) portion of Hells Canyon Creek was mixed coniferous, dominantly deciduous forest (**Figure 2-32**). Buffer width was generally less than 50 feet wide along both sides of the stream. The relative health category assigned to Reach 9 was 'Fair' due to development near the floodplain. During the field review, cottonwood (with some runners), willows, alder, rose, and grasses were noted as extending generally to a maximum of 40 feet from the channel. Thistles were also present. Between 1983 and 2001, the riparian buffer width in Reach 9 appeared to increase by an average of 15 percent.

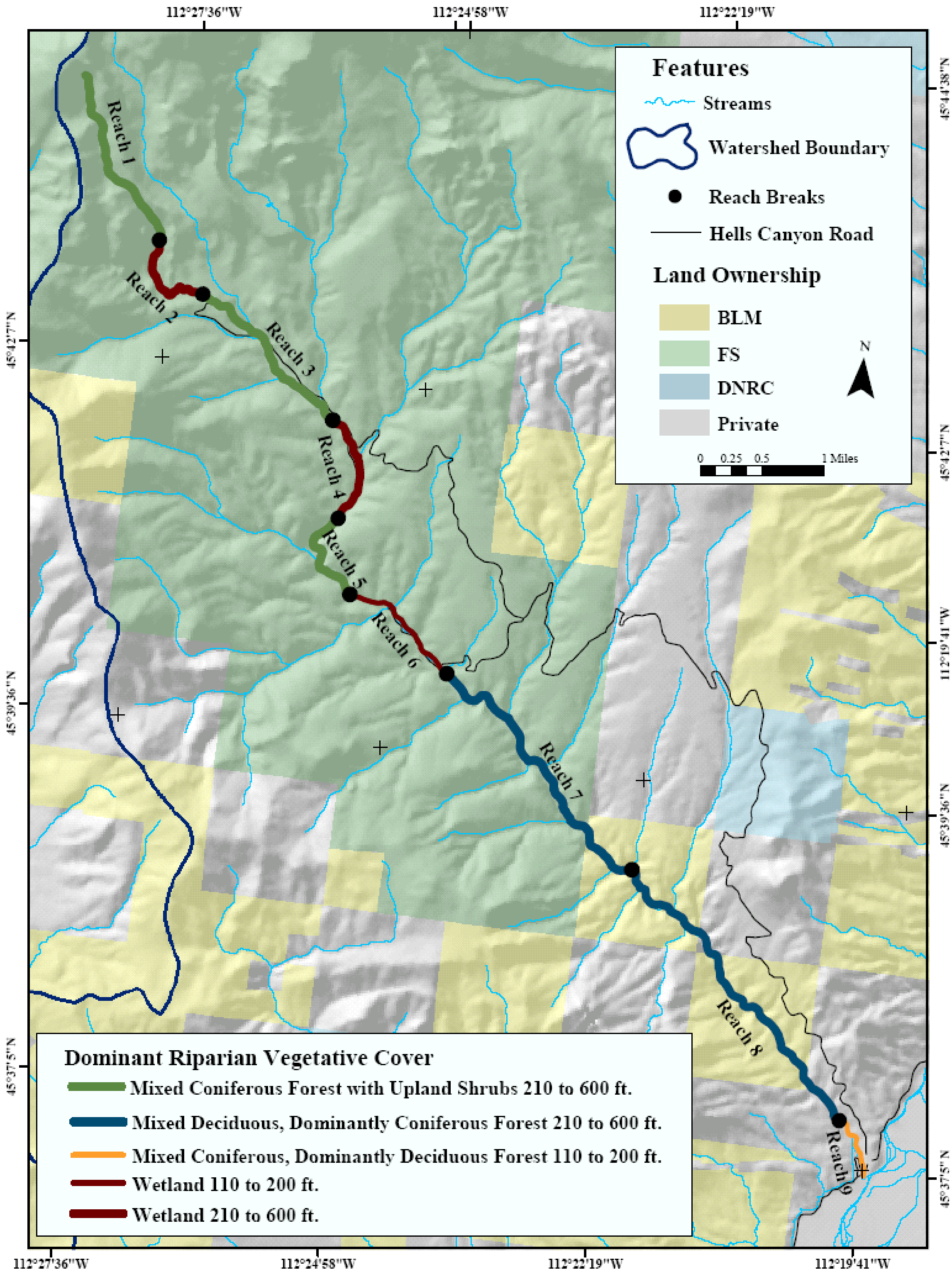

Figure 2-32. Hells Canyon Creek Riparian Vegetation

2.2.7.3 Hells Canyon Creek Pollution Sources

Figure 2-33 displays the pollution sources assigned to Hells Canyon Creek. Most pollution sources observed along upper Hells Canyon Creek were related to riparian grazing and unpaved roads. The sources of flow alterations from water diversions and impacts from abandoned mine lands were taken from GIS layers which located water rights claims and abandoned mines. The GIS identified sources were not field verified. Silviculture harvests occurred before 1983, upslope from and adjacent to Hells Canyon Creek. Any runoff associated with the harvests would enter in Reaches 2 through 4. Harmful effects from this impact were not observed in the field. Loss of riparian habitat was generally associated with road development and grazing. There were no significant changes in pollution sources between 1983 and 2001.

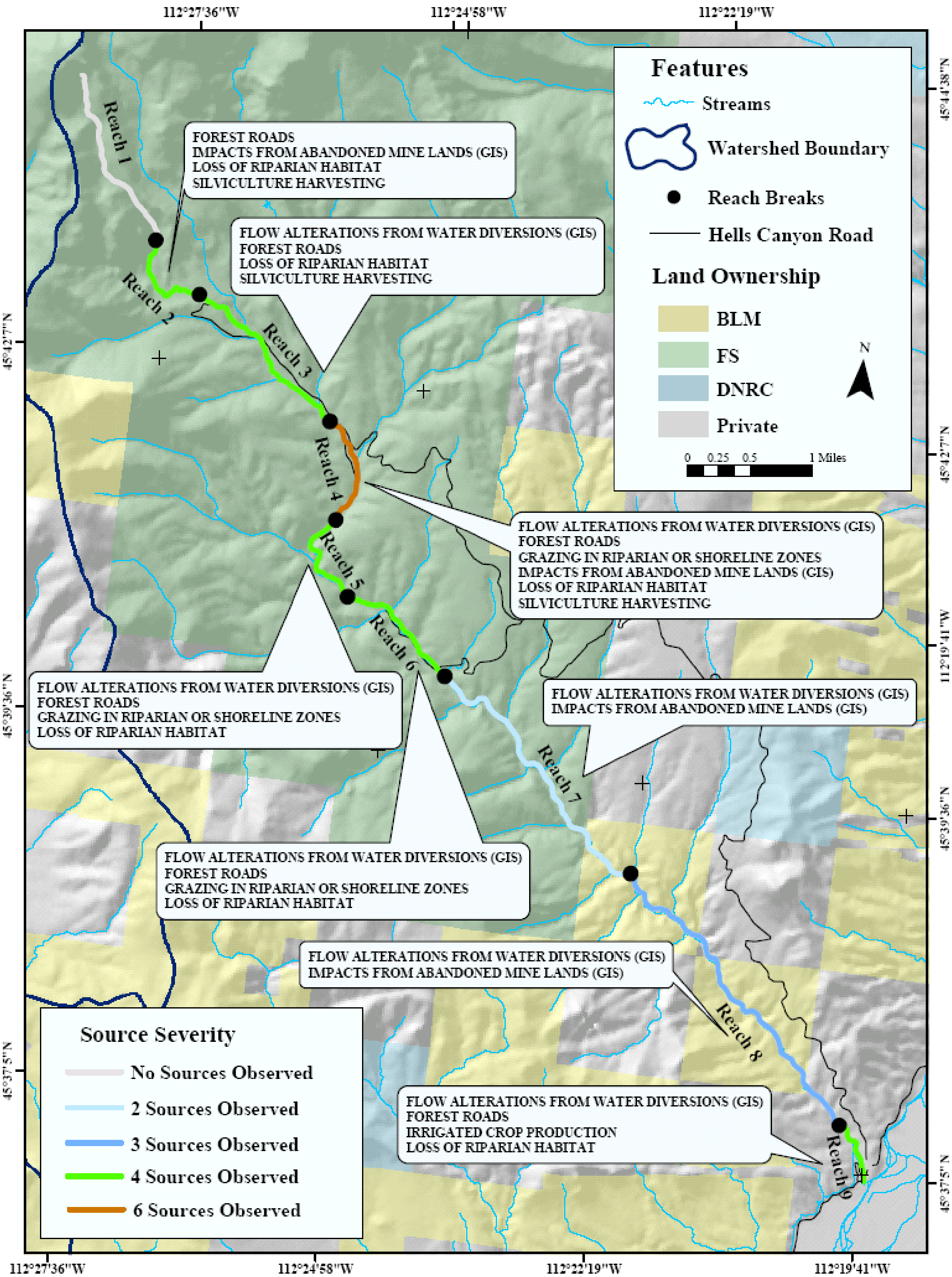

Figure 2-33. Hells Canyon Creek Pollution Sources

2.2.8 Little Pipestone Creek

Little Pipestone Creek headwaters on the Continental Divide in the Beaverhead-Deerlodge National Forest. It flows for approximately 16 miles to where it meets Big Pipestone Creek. The suspected causes of impairment to Little Pipestone Creek are bank erosion, habitat alteration, riparian degradation, and siltation. Suspected pollution sources to Little Pipestone Creek include agriculture, channelization, grazing related sources, and hydromodification. According to the 2004, 303(d) List, cold water fisheries and associated aquatic life are partially supported uses.

For the purposes of the source assessment, Little Pipestone Creek was broken into 10 reaches (**Figures 2-34** to **2-39**). During the October field source assessment, 5 of the 10 reaches were visited in the field (**Table 2-8**). Stream access on private property was somewhat limited. Where available, field information was incorporated within the results of the source assessment.

Table 2-8. Field Assessment of Little Pipestone Creek Reaches

Little Pipestone Creek Reach Number	Visit Purpose	Percent of Reach Surveyed
Reach 1	Field Survey	20%
Reach 2	Field Survey	Less than 20%
Reach 3	Field Survey	10%
Reach 8	Field Survey	Less than 5%
Reach 10	Field Survey	25%

2.2.8.1 Little Pipestone Creek Rosgen Stream Types

The channel forms of Upper Little Pipestone Creek are predominantly controlled by landform structure, as well as historical and current landuse activities (**Figure 2-34**). The channel forms of Little Pipestone Creek in Reaches 1 to 3 were difficult to type in areas because of channelization and grazing impacts. As well during the aerial review, the channel was not visible until Reach 4. For these reasons, the channel classifications for Reaches 1, 2, and 3 were changed to 'unclassified' after the field review. The area surveyed in Reach 1 was more of a flooded wet meadow than an actual stream. There were ponded areas from earthen dams, and some areas of multiple threads with E-type channel characteristics. Reach 2 was affected by channelization between Highway 2 and the railway. Channel forms observed in Reach 2 were characteristic of E and mostly G-type streams. The portion of Reach 3 observed in the field trended from an Eb to a B-type channel. The channel was less confined in Reaches 4, 5, and 7, and was thought to have characteristics on an E-type channel. Structural controls in Reach 6 led to the classification of a B-type reach. The Boulder Batholith is the prominent geology of the upper reaches. There were no significant changes in channel form between 1983 and 2001.

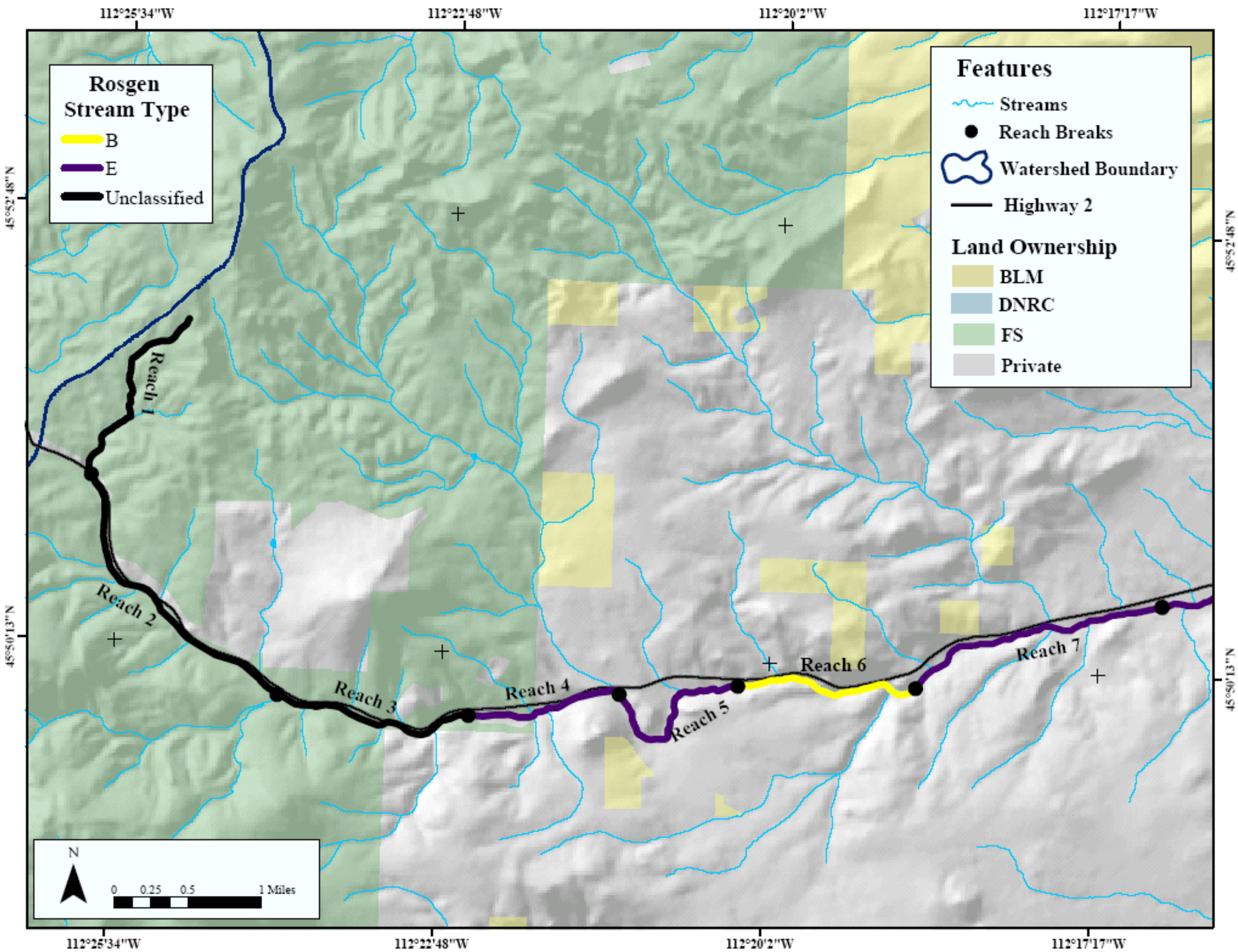

Figure 2-34. Upper Little Pipestone Creek Rosgen Stream Types

The channel forms of Lower Little Pipestone Creek are also predominantly controlled by landform structure, and historical and current landuse activities (**Figure 2-35**). The predominant valley type (VIII) would typically result in an unconfined stream type (C or E), yet channel alterations have resulted in stream types out of balance with the valley type (directly observed in Reach 10). The small section of Reach 8 viewed in the field exhibited E-type channel characteristics. Active beaver dams were observed on the creek above Highway 41 in this reach. It is suspected that channel form in Reach 9 could possibly be an F-type due to the Delmoe Ditch irrigation diversion and disruption of riparian habitat in this reach. Observed channel forms in Reach 10 were variable, but an overall classification of F-type was given to this reach. Areas of braiding were observed, along with overwidened sections, as well as a large downcut section. For the lower portion of Little Pipestone Creek, only one time period was analyzed so significant changes in channel form since 1983 could not be determined.

2.2.8.2 Little Pipestone Creek Riparian Vegetation

Riparian cover along Upper Little Pipestone Creek was variable (**Figure 2-36**). The predominant cover in Reaches 1 and 2 was wetland vegetation. Field assessment in Reaches 1 and 2 revealed that the willows were decadent from heavy browsing, and dying in areas due to ponding. Buffer widths were limited in Reaches 2, 3, and 6 by proximity to the highway. Riparian vegetation type in Reaches 3 and 6 was mixed coniferous forest with upland shrubs. Development in Reaches 4 and 5 resulted in a loss of woody vegetation, and the classification was changed to predominantly herbaceous. Woody vegetation generally extended to a maximum of 20 feet on either side on the channel in these reaches. The relative health category assigned to the riparian vegetation progressed from excellent to poor in a downstream manner. There were no significant changes in riparian vegetation between 1983 and 2001.

Riparian vegetative cover along Lower Little Pipestone Creek progressed from predominantly deciduous, to wetland, to herbaceous (**Figure 2-37**). Buffer widths were generally less than 50 feet wide along both sides of the stream, except for in Reach 8. The relative health category assigned to the lower reaches progressed from ‘Fair’ to ‘Poor’ in a downstream manner. During the field review, decadent hedged willows and sedges were noted as extending to a maximum of 20 feet from the channel in Reach 10. For the lower portion of Little Pipestone Creek, only one time period was analyzed so significant changes in riparian vegetation since 1983 could not be determine

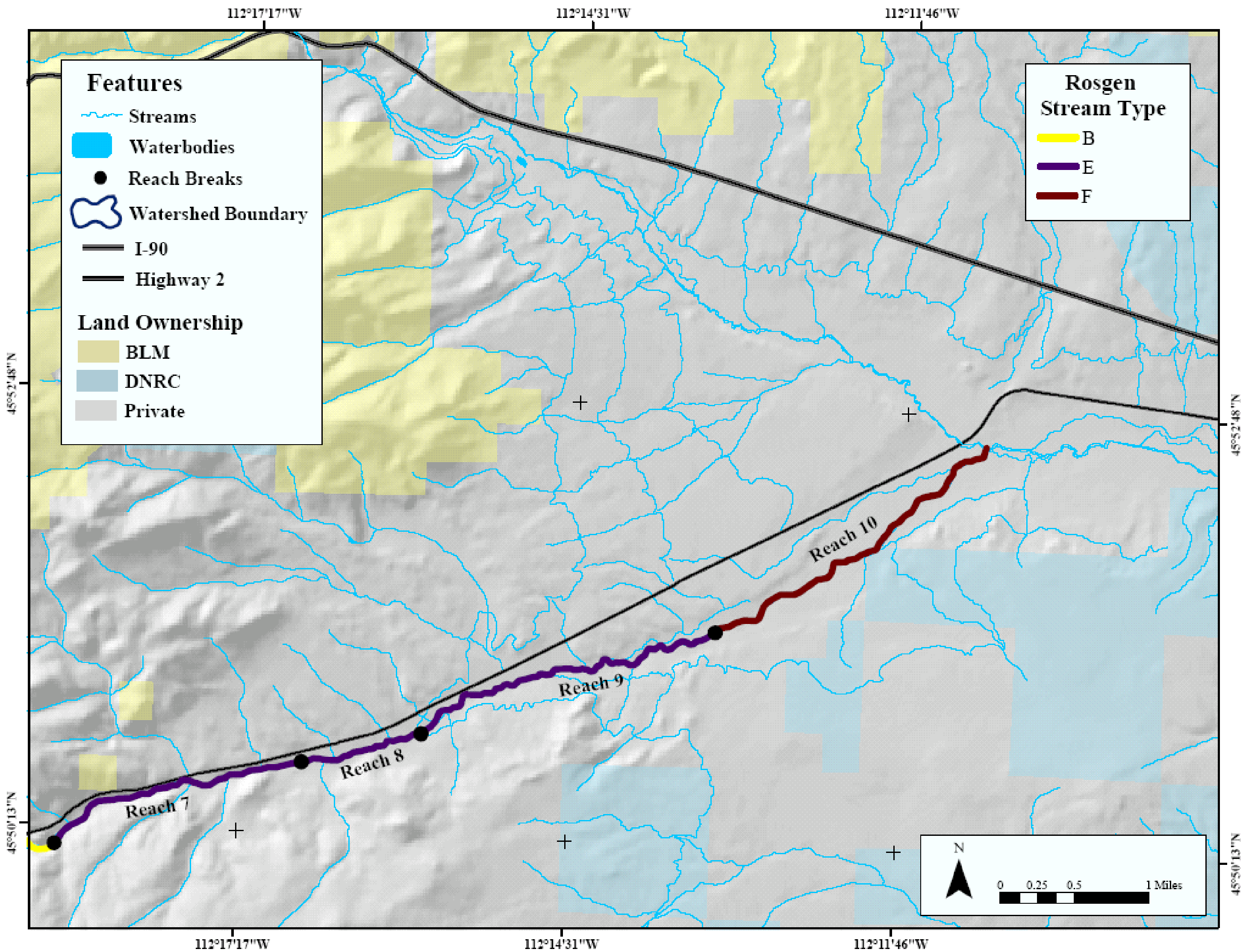

Figure 2-35. Lower Little Pipestone Creek Rosgen Stream Types

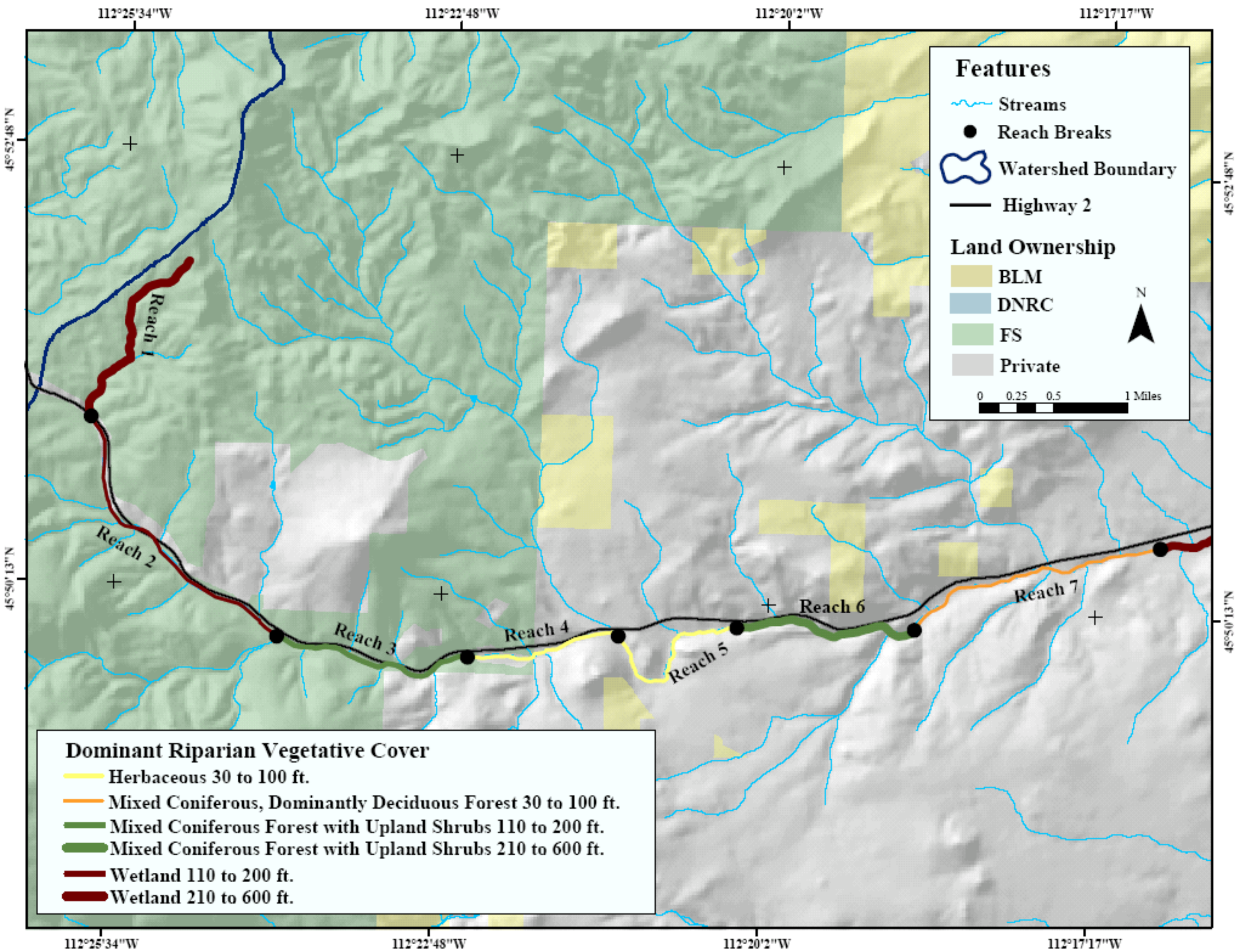

Figure 2-36. Upper Little Pipestone Creek Riparian Vegetation

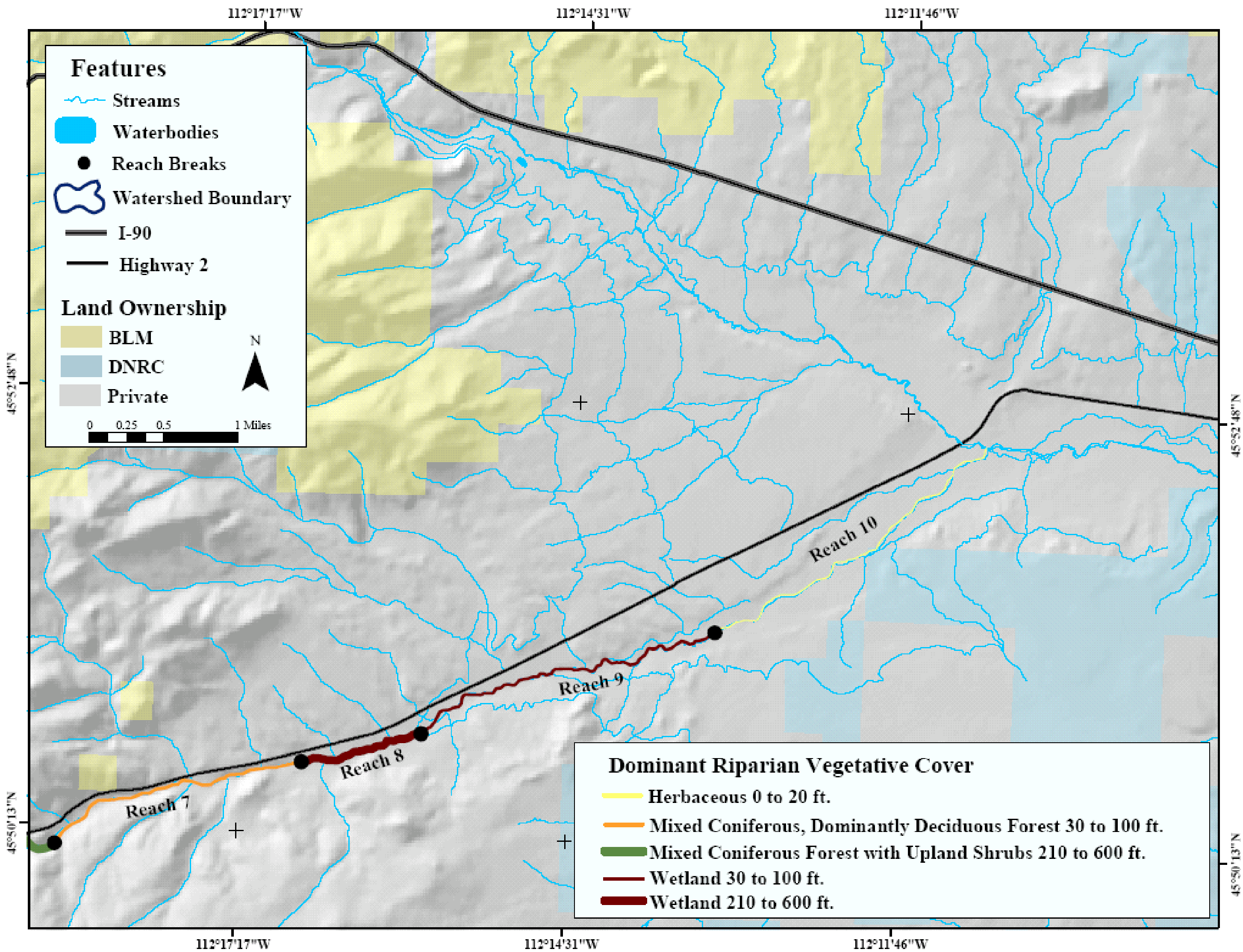

Figure 2-37. Lower Little Pipestone Creek Riparian Vegetation

2.2.8.3 Little Pipestone Creek Pollution Sources

Figure 2-38 displays the pollution sources assigned to the upper reaches of Little Pipestone Creek. Many pollution sources observed along Upper Little Pipestone Creek were related to roads and riparian grazing. In many instances, the sources of flow alterations from water diversions and impacts from abandoned mine lands were taken from GIS layers which located water rights claims and abandoned mines. The GIS identified sources were not field verified, except in Reach 1 where 3 earthen dams have obstructed the channel. A large road sediment source was observed entering the creek in Reach 2. Channelization effects were prominent in Reaches 2 and 3. There were no significant changes in pollution sources between 1983 and 2001.

Figure 2-39 displays the pollution sources assigned to the lower reaches of Little Pipestone Creek. Many pollution sources observed along Lower Little Pipestone Creek were related to agricultural operations and rural housing development. Alterations for irrigation diversions were observed in reaches 9 and 10. During the field source assessment, grazing impacts and flow alterations were observed in Reach 10. In general, stream condition deteriorates in a downstream manner from Reach 8 to Reach 10. For the lower portion of Little Pipestone Creek, only one time period was analyzed so significant changes in pollution sources since 1983 were not be determined.

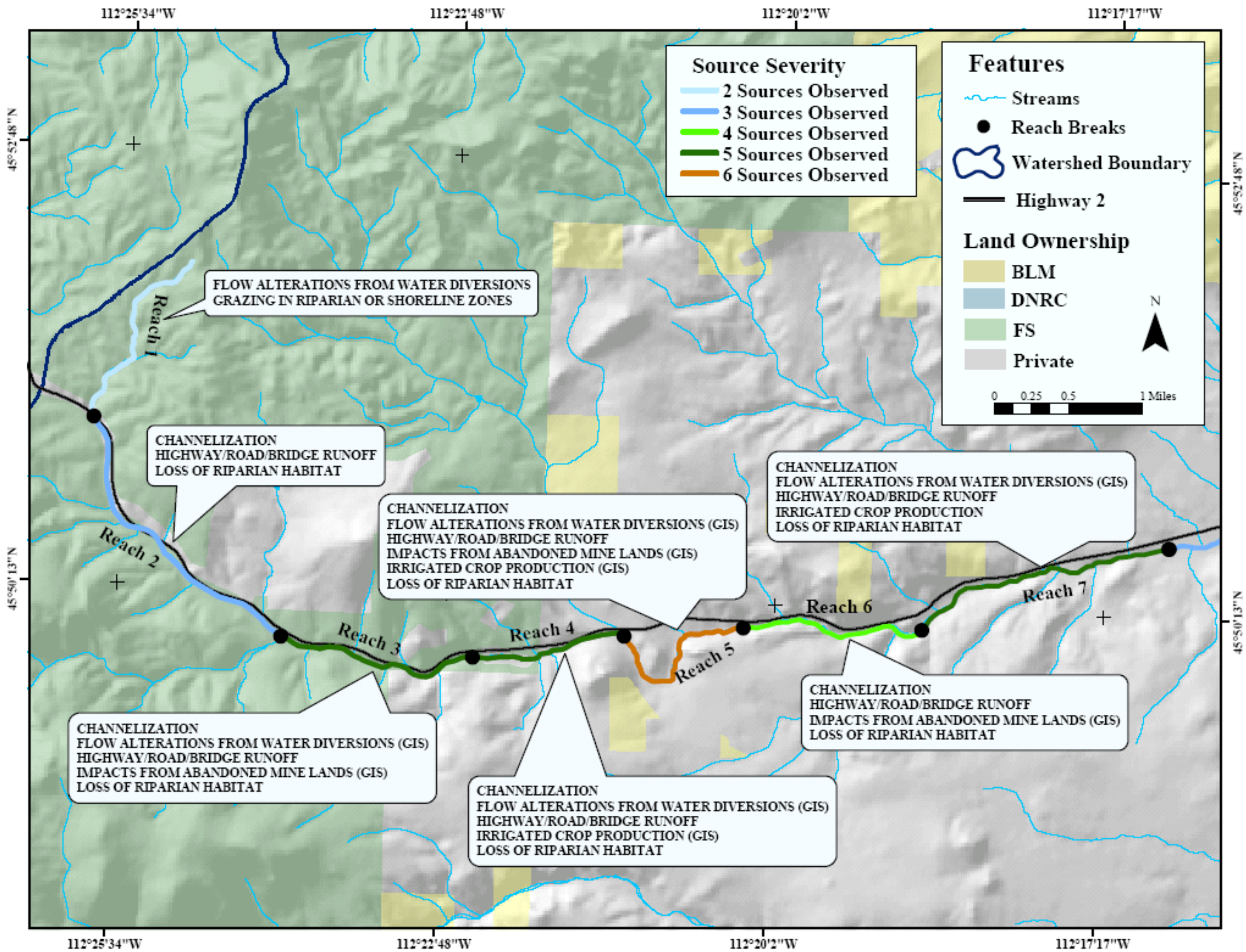

Figure 2-38. Upper Little Pipestone Creek Pollution Sources

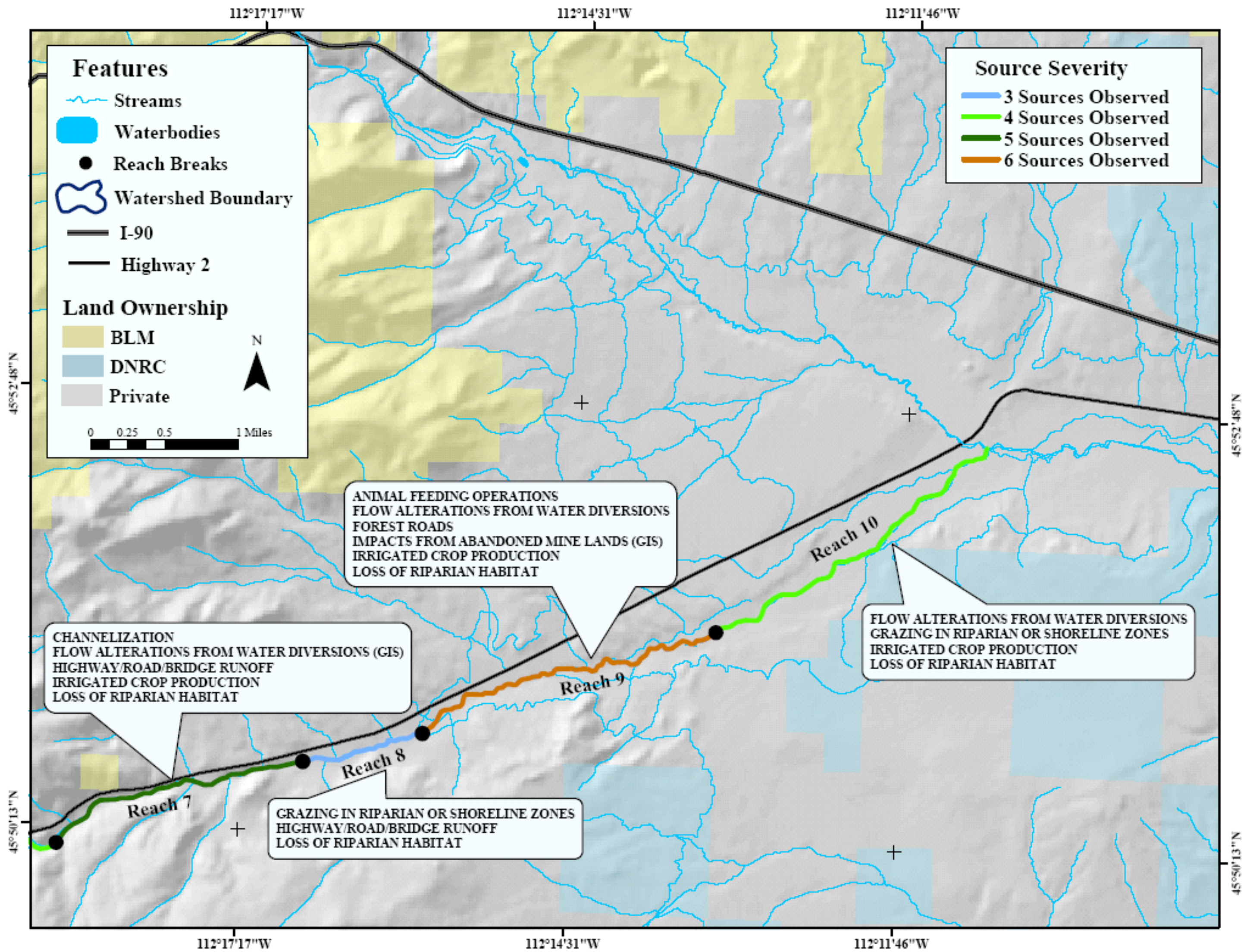

Figure 2-39. Lower Little Pipestone Creek Pollution Sources

2.2.9 Whitetail Creek

Whitetail Creek forms at the outlet of Whitetail Reservoir on the Beaverhead-Deerlodge National Forest. It flows for approximately 23 miles to where it meets the Jefferson Slough, a former channel of the Jefferson River. The suspected causes of impairment to Whitetail Creek are dewatering/flow alterations, habitat alterations, riparian degradation, and siltation. Suspected pollution sources to Whitetail Creek include agriculture, flow regulation/modification, grazing related sources, and hydromodification. According to the 2004 303(d) List, cold water fisheries and associated aquatic life, and primary contact recreation are partially supported water uses; while drinking water supply use has not been assessed.

For the purposes of the source assessment, Whitetail Creek was broken into 17 reaches (**Figures 2-40** to **2-45**). During the 2004 water quality monitoring project (May to September) and the October field source assessment, 8 of the 17 reaches were visited in the field (**Table 2-1**). Where available, field information was incorporated within the results of the source assessment.

Table 2-8. Field Assessment of Whitetail Creek Reaches

Whitetail Creek Reach Number	Visit Purpose	Percent of Reach Surveyed
Reach 5	Field Survey	25%
Reach 6	Field Survey	Less than 5%
Reach 12	Field Survey	30%
Reach 13	Field Survey	70%
Reach 14	Field Survey, Water Quality Monitoring	40%
Reach 15	Water Quality Monitoring	Less than 5%
Reach 16	Field Survey	40%
Reach 17	Water Quality Monitoring	Less than 10%

2.2.9.1 Whitetail Creek Rosgen Stream Types

The channel forms of Upper Whitetail Creek are predominantly controlled by landform structure, and flow releases from Whitetail Reservoir (**Figure 2-40**). The landform geology of Reaches 1 to 6 is the Boulder Batholith, while intrusive volcanic rocks are prominent in reaches 7 to 12. The stream headwaters in Whitetail Park at the outlet of Whitetail Reservoir (C-type) and then flows through a steep, narrow canyon (A-type). The canyon gradient lessens and valley bottom openings alternate between relatively confined (B-type reaches), and unconfined areas (C-type reaches). The area of Reach 5 viewed during the field survey exhibited a C-type channel with transformation to a B-type channel at the end of the reach. The beginning of Reach 6 was noted as a good potential for a reference B-type channel. Reach 12 was observed as a B-type channel trending to C-type in less confined areas, while Reach 13 had characteristics of a C-type channel. There were no significant changes in channel form between 1983 and 2001.

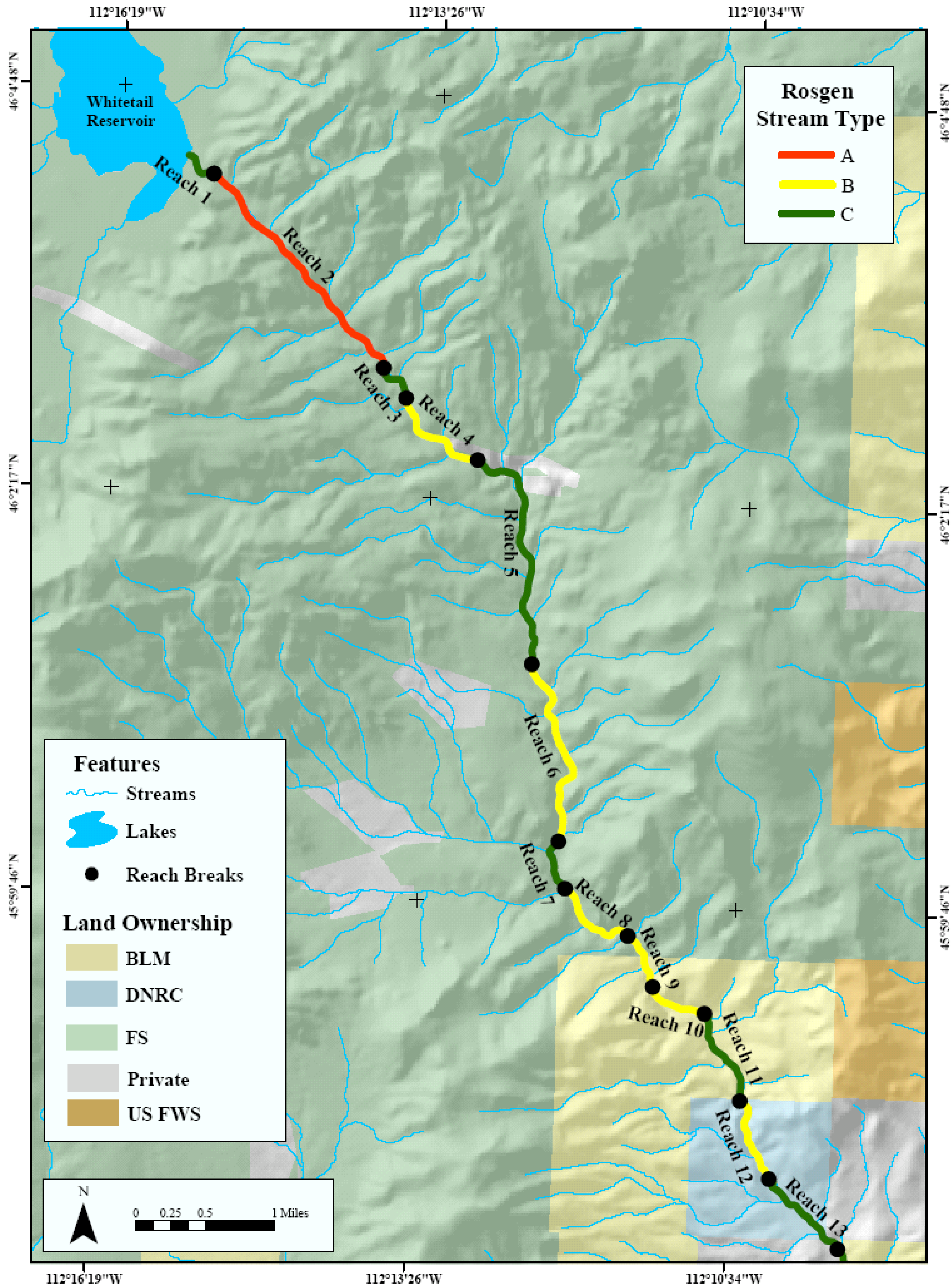

Figure 2-40. Upper Whitetail Creek Rosgen Stream Types

The channel forms of Lower Whitetail Creek are controlled by landform and historical and current landuse activities (**Figure 2-41**). The predominant valley type (VIII) would typically

result in an unconfined stream type (C or E), yet alterations for flow diversions and possibly removal of beaver dams have resulted in sections of the stream with channel types out of balance with the valley type. The width to depth ratio in Reach 14 was lower than in reach 13 and was moderately entrenched in areas. This was thought to be related to a large diversion which diverts flow in the upper part of Reach 14. Channel form in Reach 14 exhibited C-type and Bc-type characteristics. After the confluence with Little Whitetail Creek, sinuosity greatly increases and the stream was thought to exhibit an E-type channel in Reaches 15 to 17. Most of the areas surveyed in Reach 16 exhibited E-type channel characteristics. Active beaver dams were observed in Reaches 16 and 17. There was also a notable difference in 'beaver management' along the stream depending on individual landowner, with beaver dams concentrated in some areas and totally absent in others. It is thought that active beaver dams in Reach 16, as well as beaver dam removal have resulted in diverse channel forms, such as braided sections and incised sections. For the lower portion of Whitetail Creek, only one time period was analyzed so significant changes in channel form since 1983 could not be determined.

2.2.9.2 Whitetail Creek Riparian Vegetation

The dominant riparian cover along Upper Whitetail Creek in Reaches 1 to 6 was mixed coniferous forest with upland shrubs (**Figure 2-42**). During the field review in Reach 5, sedges, alder, and willows were observed extending about 10 feet from the channel within the conifer forest. Riparian cover from Reaches 7 to 13 alternated between wetland (less confined valley bottom areas), mixed coniferous forest, and deciduous forest. Buffer widths were generally limited by valley bottom width and the availability of moisture. The relative health categories assigned to all of the upper reaches was either 'Excellent' or 'Fair', depending on whether disturbance was visible. Some areas of thistle infestation were observed in Reaches 5 and 13. Buffer widths were generally greater than 100 feet wide along both sides of the stream, and represented the distance of vegetation surrounding the stream before any disturbance was observed. There were no significant changes in riparian vegetation between 1983 and 2001.

Riparian cover along Lower Whitetail Creek transitioned from herbaceous, to wetland, to herbaceous (**Figure 2-43**). This is largely a reflection of landuse. It is suspected that a lowering of the water table in Reach 14 is one factor in the decrease of deciduous vegetation. During the field survey in Reach 14, decadent and dying cottonwood, intermixed with willow, alder, current, and red osier were confined to a narrow corridor along stream. Reaches 15 and 16 were dominated by willows. The riparian area appeared to be more intact in Reach 15 than in Reach 16, and may reflect the fact that land ownership was more subdivided in Reach 16 versus Reach 15. The herbaceous category for Reach 17 was due to development and farming in the riparian zone. The relative health category assigned to most of the lower reaches was: 'Poor'. For the lower portion of Whitetail Creek, only one time period was analyzed so significant changes in riparian vegetation since 1983 could not be determined.

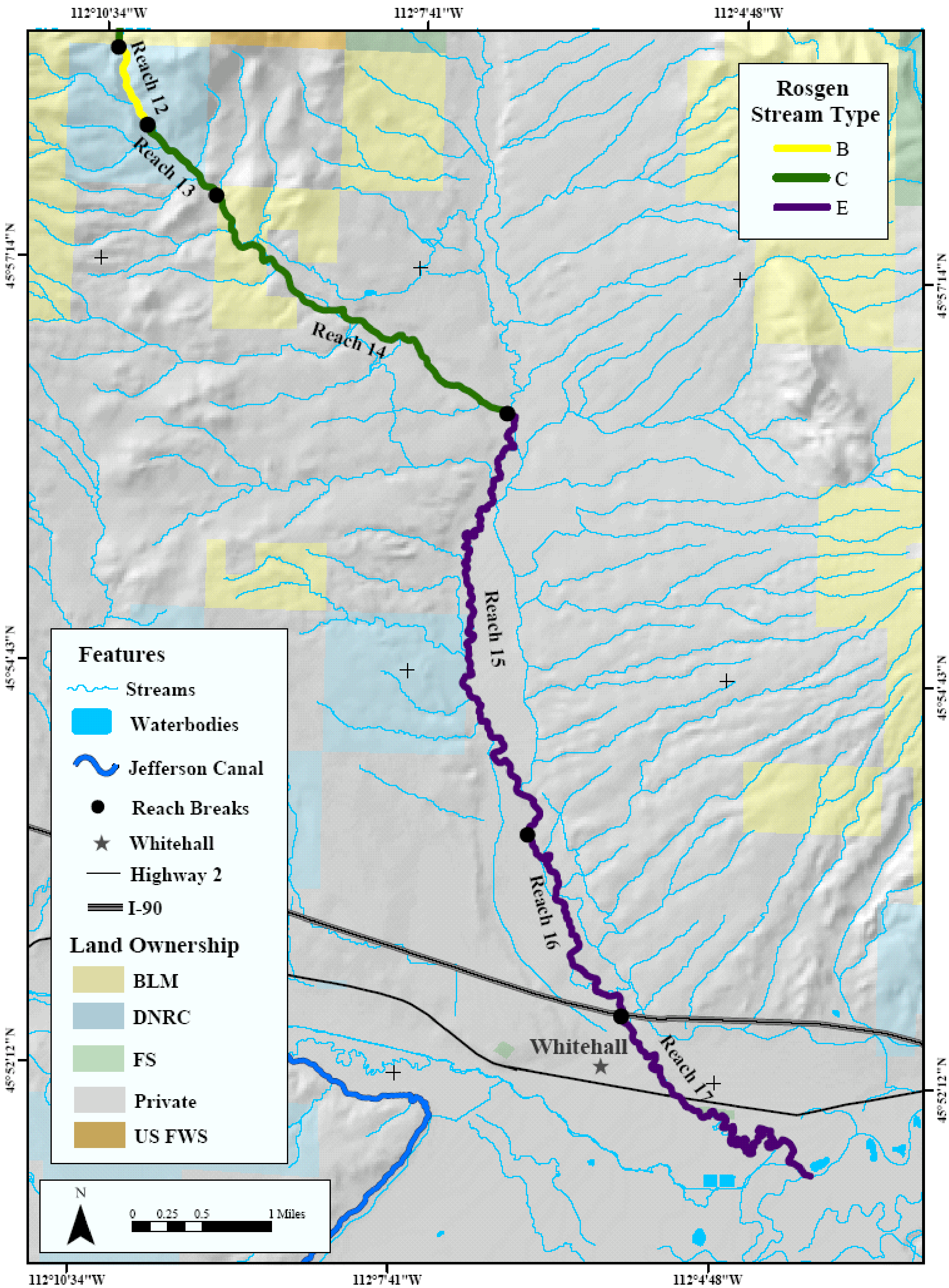

Figure 2-41. Lower Whitetail Creek Rosgen Stream Types

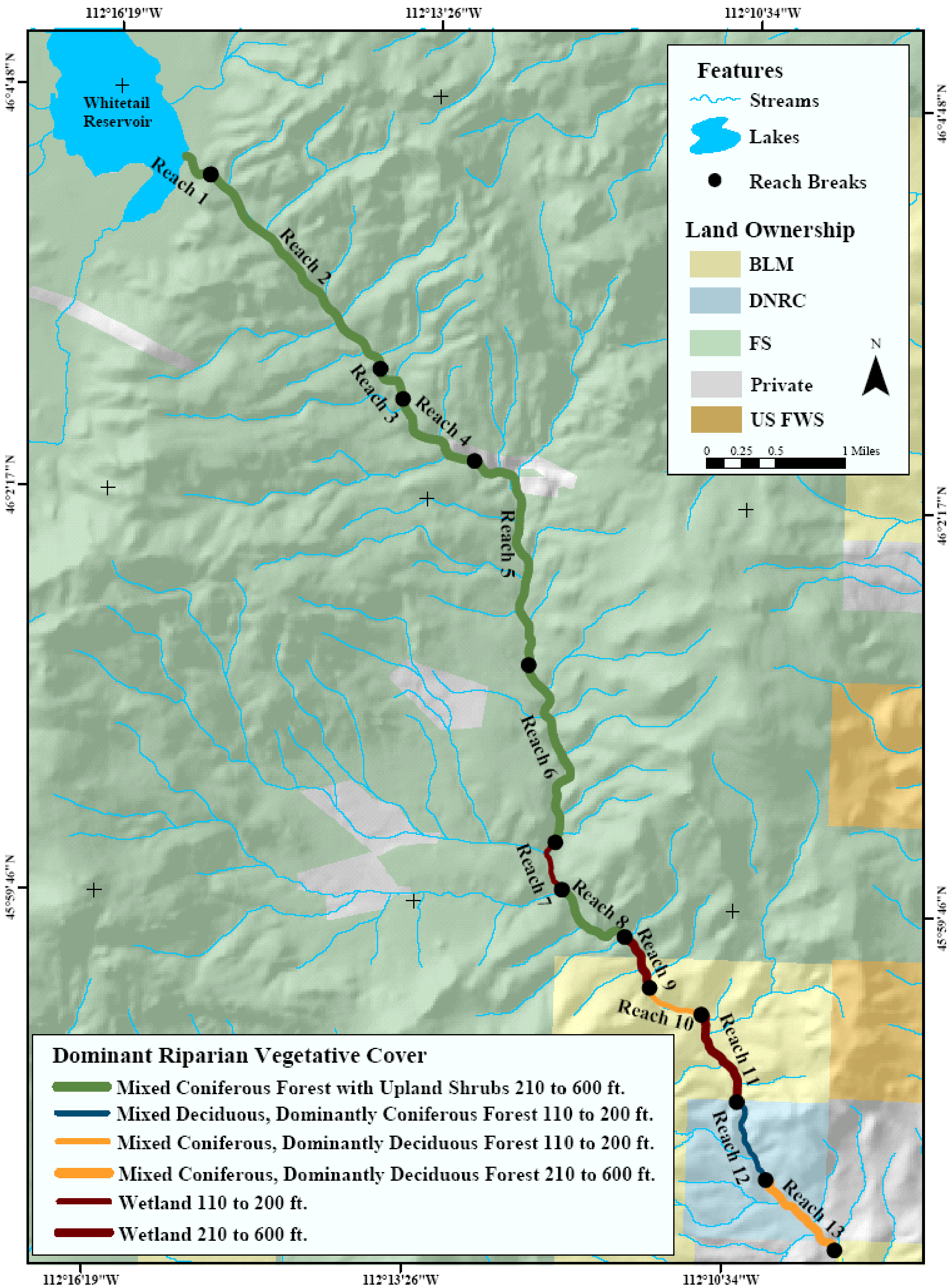

Figure 2-42. Upper Whitetail Creek Riparian Vegetation

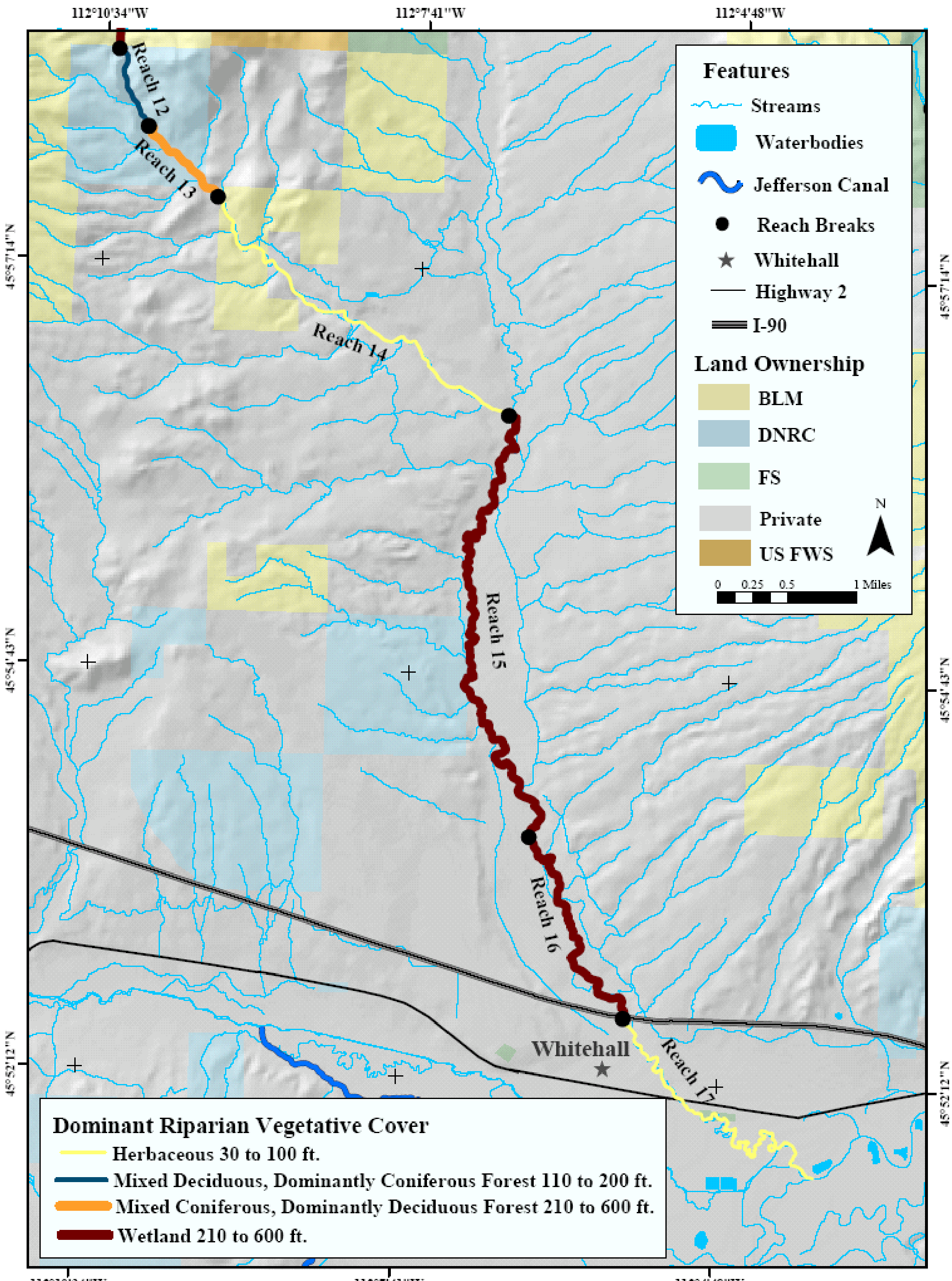

Figure 2-43. Lower Whitetail Creek Riparian Vegetation

2.2.9.3 Whitetail Creek Pollution Sources

Figure 2-44 displays the pollution sources assigned to the upper reaches of Whitetail Creek. In many instances, the sources of flow alterations from water diversions and impacts from abandoned mine lands were taken from GIS layers, and were not field verified. Most of the pollution sources observed in the field along Upper Whitetail Creek were related to the riparian grazing and unpaved roads (Reaches 5 and 13). Brown trout were observed in the upper reaches of Whitetail Creek during the October field assessment. During the aerial assessment of the 1983 photos, disturbance below a prospect area was visible in Reach 4, but was not visible in 2001. In 1983, beaver ponds were visible on two major tributaries to Whitetail Creek: Grouse Creek and Gillespie Creek (Reach 7), but were gone by 2001.

Figure 2-45 displays the pollution sources assigned to the lower reaches of Whitetail Creek. Many pollution sources observed along Lower Whitetail were related to agricultural operations. During the field source assessment, grazing impacts were observed in all of the field surveyed reaches. Alterations for irrigation diversions were observed in reaches 14, 16, and 17. The sources observed were localized by the property owner's land use, such as confined feedlots, removal of riparian vegetation, and small grazing pastures. For the valley portion of Whitetail Creek, only one time period was analyzed so significant changes in pollution sources since 1983 were not be determined.

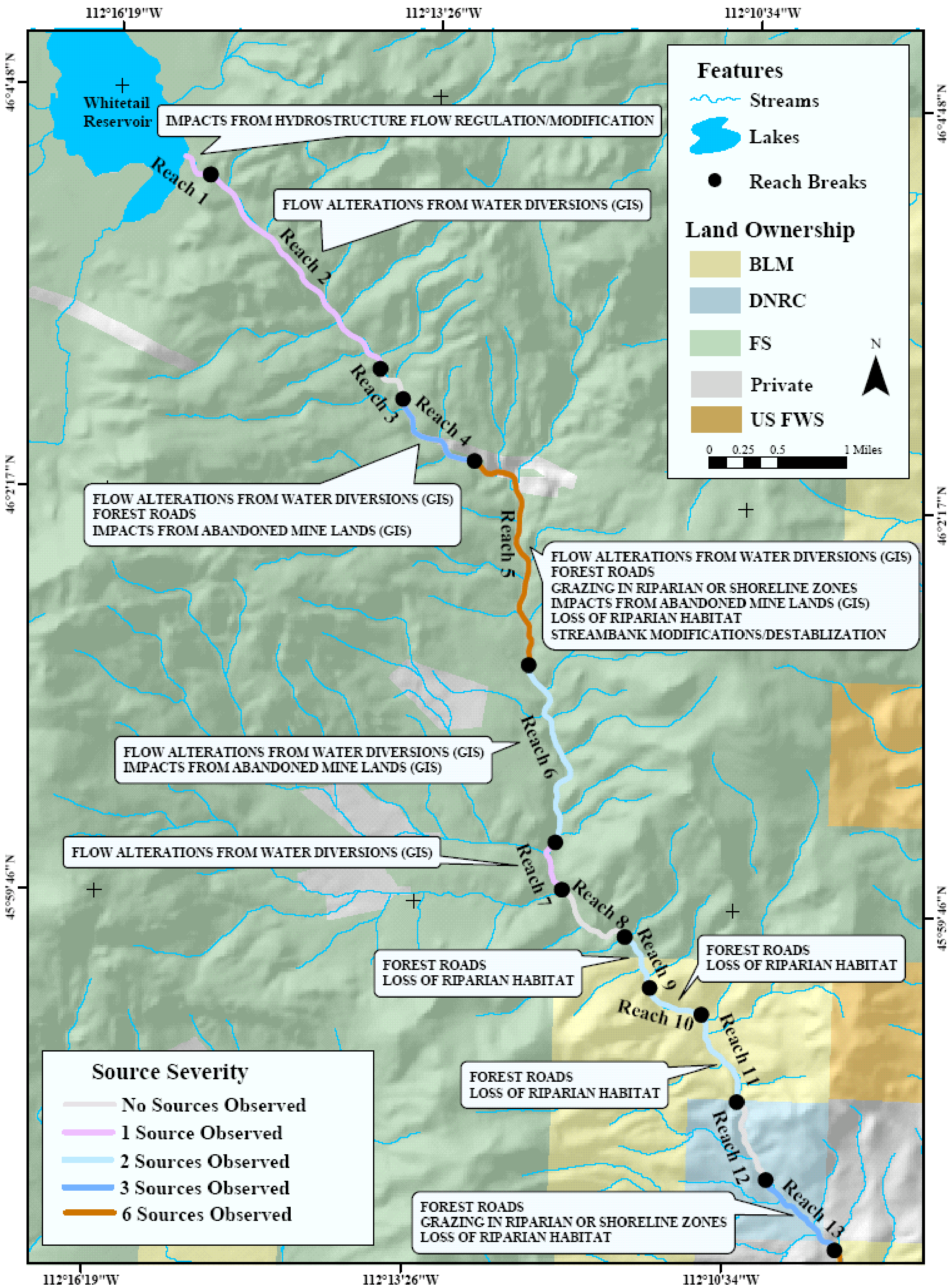

Figure 2-44. Upper Whitetail Creek Pollution Sources

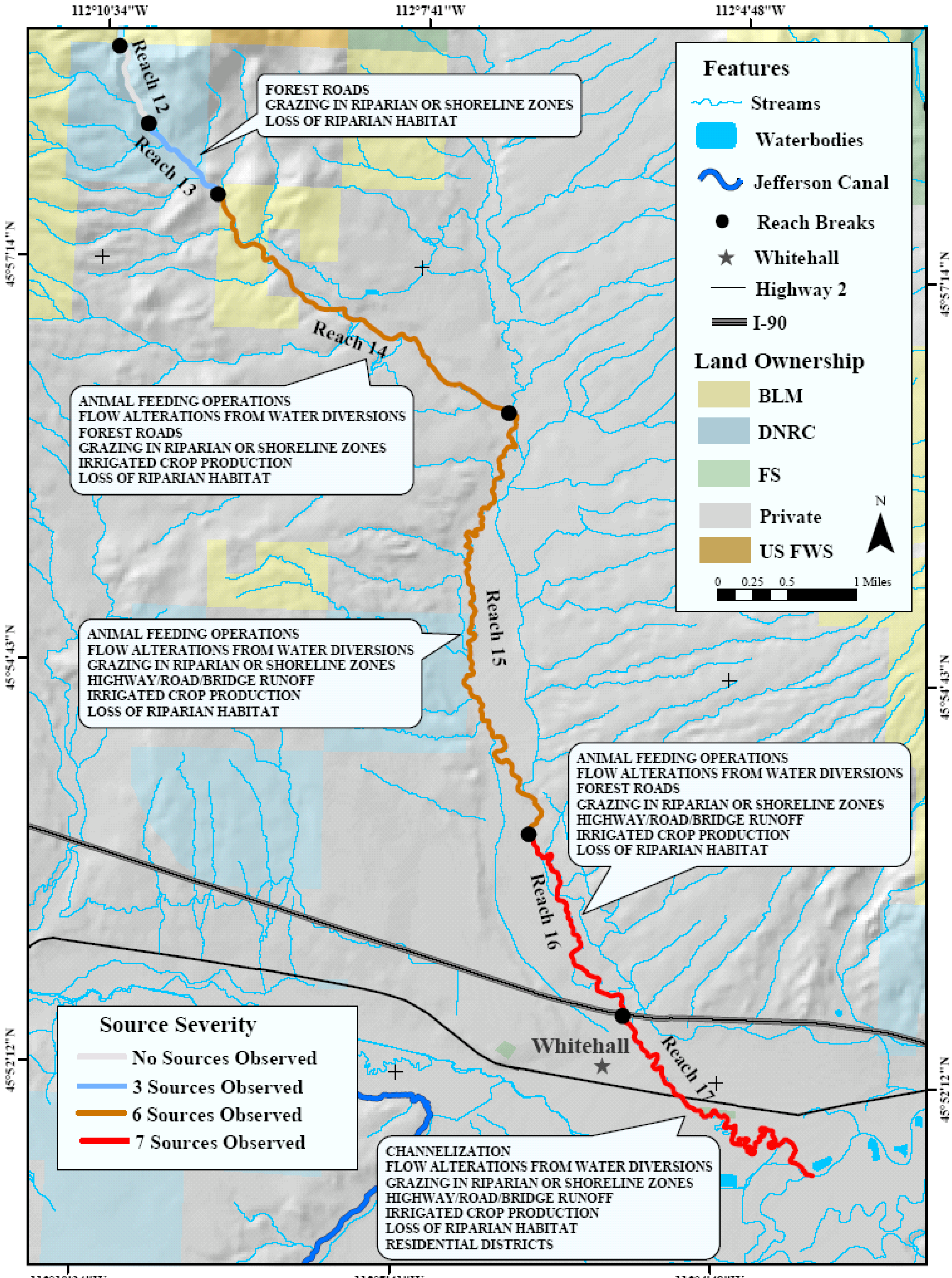

Figure 2-45. Lower Whitetail Creek Pollution Sources

2.2.10 Upper Jefferson River

The Jefferson River forms at the confluence of the Big Hole and Beaverhead Rivers in Madison County. It flows for approximately 84 miles to where it meets the Madison and Gallatin rivers at Three Forks, MT to form the Missouri River. The upper portion of the Jefferson River consists of the 42 mile section from the headwaters to the confluence with the Boulder River. The suspected causes of impairment to the Jefferson River are copper and lead, dewatering/flow alterations, habitat alterations, suspended sediment/siltation, and thermal modifications. Suspected pollution sources to the Jefferson River include abandoned mines, agriculture, bank modification/destabilization, flow regulation/modification, habitat modification, hydromodification (dams), removal of riparian vegetation, and resource extraction. According to the 2004 303(d) List, cold water fisheries and associated aquatic life, and drinking water supply uses are not supported; while industry and primary contact recreation are partially supported uses.

For the purposes of the source assessment, the Upper Jefferson was broken into 14 reaches (**Figures 2-46** to **2-49**). As mentioned earlier, no reaches were visited in the field during the October 2004 source assessment. During the 2004 water quality monitoring project (May to September), sections of Reach 2 and Reach 13 were visited in the field.

2.2.10.1 Upper Jefferson River Rosgen Stream Types

Reach designations for the Upper Jefferson River were made under the assumption that the river was predominantly a single channel. This decision was based on information collected during the 2003 Hoitsma Ecological riparian assessment, as well as Rosgen classification techniques based on valley type (VIII). Reach breaks were divided on the basis of meander wavelength, channel confinement, aspect, and adjacent landuses. After the analysis was conducted on the 2002 images, the channel was viewed with a more encompassing perspective on the 1983 aerial photographs (limited channel overview on a computer screen at 1:10,000, and 2002 images did not capture all of the channels). It was then determined that many of the reach designations do not fit wholly within one Rosgen channel type. It is the professional opinion of the analyst that the Upper Jefferson River is part of a 'multi-channel system', a term used by Dr. Steve Custer of Montana State University. The multi-channel system describes the concept of multiple channels with different channel patterns existing in a single system (Custer, 2001). This concept fits well for the Jefferson River due to the presence of gravels bars, large vegetated islands, and multiple channel threads.

An overall Rosgen stream type was assigned to the 14 designated reaches of the Upper Jefferson River (**Figures 2-46** and **2-47**). See **Table 2-9** for a review of the various channel patterns observed within the reaches. Overall Rosgen channel form changed for Reaches 4, 6, 11, 13, and 14 between 1983 and 1982. The changes were mostly due to the fact that drought impacts have reduced wetted channel width and exposured more gravel bars. Loss of wetted channel width has resulted in fewer channel anabraches in Reaches 6, 11 and 13; while exposure of gravel bars has increased channel braiding in Reaches 4 and 14. Subtle changes have occurred in Reaches 8, 10, and 12, but not enough to cause an overall change in the dominant channel type. It is the

professional opinion of the surveyor that without alterations for flow diversions, most of the Upper Jefferson River would be an anabranched channel.

Table 2-9. Review of Channel Patterns Found Among the Upper Jefferson River Reaches

Reach ID	Overall Rosgen Channel Type	Comments
JEFF83-1	Da	None of measured reach is single thread. Anabranching channel with braided areas through non-vegetated bars.
JEFF02-1	Da	Anabranching channel with areas of braiding through non-vegetated bars.
JEFF83-2	D	Channel alternating between D and Da. A large Oxbow meander to the right bank before end of the reach is still connected to the channel (anabranch). Mostly D
JEFF02-2	D	Channel alternating between D and Da. A large Oxbow meander the right bank before the end of the reach is still connected to the channel (anabranch). Mostly D
JEFF83-3	D	Channel alternates between D, C, and Da, with an anabranch at the end of the reach. Anabranched areas appear to be influenced by irrigation diversion canals. Channel confinement evident along portions of the reach. Mostly D
JEFF02-3	D	Channel alternates between D, C, and Da, with an anabranch at the end of the reach. Anabranched areas appear to be influenced by irrigation diversion canals. Channel confinement evident along portions of the reach. Mostly D
JEFF83-4	Unclassified	Channel alternates between C, D and Da. Point bars are visible, with anabranching near the end of the reach.
JEFF02-4	D	Channel alternates between D and C. Possible anabranching in areas if water levels were higher. Mostly D.
JEFF83-5	Da	Main channel is mostly single thread with point bars and some braiding. A large side channel to the right bank that breaks off in Reach 4 gives the reach characteristics of Da channel. 2 Oxbows are located on the on the left bank near the end of the reach with connection to main channel.
JEFF02-5	Da	Main channel is mostly single thread with point bars and some braiding. A large side channel to the right bank that breaks off in Reach 4 gives the reach characteristics of Da channel. 2 Oxbows are located on the on the left bank near the end of the reach with connection to main channel.
JEFF83-6	Unclassified	Main channel is single thread channel (C) with braiding through detached point bars and near end of reach. Flow entering from a former channel in middle of the reach on the right bank (probably influenced by groundwater and irrigation return flow). The stream anabranches just downstream of the former channel.

Table 2-9. Review of Channel Patterns Found Among the Upper Jefferson River Reaches

Reach ID	Overall Rosgen Channel Type	Comments
JEFF02-6	C	Main channel is single thread channel (C) with braiding through detached point bars and near end of reach. Flow entering from a former channel in middle of the reach on the right bank (probably influenced by groundwater and irrigation return flow).
JEFF83-7	Da	Reach begins as a single thread channel and at about 1 meander wavelength anabranching begins. There is some braiding through gravel bars. Flow enters on the left bank before end of reach from a side channel that forms in the valley.
JEFF02-7	Da	Reach begins as a single thread channel and at about 1 meander wavelength anabranching begins. There is some braiding through gravel bars. Flow enters on the left bank before end of reach from a side channel that forms in the valley.
JEFF83-8	C	Mostly single thread channel. Beginning of reach is the end of an anabranch, and near the end of reach the channel is braided (not in 2001). Some shorter areas of braiding around detached vegetated point bars.
JEFF02-8	C	Mostly single thread channel. Beginning of reach is the end of an anabranch, with a few areas of braiding.
JEFF83-9	Da	Channel alternates between C, D, and Da. Begins as a single thread and about halfway becomes anabranched. Lots of water entering channel in at least 4 places from former channels and irrigation drains.
JEFF02-9	Da	Channel alternates between C, D, and Da. Begins as a single thread and about halfway becomes anabranched. The end of the reach would probably have more channels if the water level was higher.
JEFF83-10	D	Channel alternates between D and Da. Anabranched areas appear to be influenced by irrigation diversion canals.
JEFF02-10	D	Channel alternates between D and C, mostly D.
JEFF83-11	Da	Channel alternates between D and Da, mostly anabranching.
JEFF02-11	C	Channel alternates between C and D, mostly C. Channel would be anabranched in sections if water was higher.
JEFF83-12	Da	Most of reach is split into 2 main channels after intersecting a backwater channel. The island between the 2 main threads is well vegetated. There are more channels visible than are visible on the 1995 Orthos.

Table 2-9. Review of Channel Patterns Found Among the Upper Jefferson River Reaches

Reach ID	Overall Rosgen Channel Type	Comments
JEFF02-12	Da	Most of reach is split into 2 main channels after intersecting a backwater channel. The island between the 2 main threads is well vegetated. Lateral channel migration visible since 1995.
JEFF83-13	D	Channel alternates between D and Da, with water entering channel in at least 3 places from former channels and irrigation drains.
JEFF02-13	C	Mostly a single thread channel, with some braiding at gravel bars. Lots of side channels/canals entering stream.
JEFF83-14	D	Channel alternates between Da and D, mostly D.
JEFF02-14	Unclassified	Channel alternates between Da, D and C. First half anabranched and braided second half single thread.

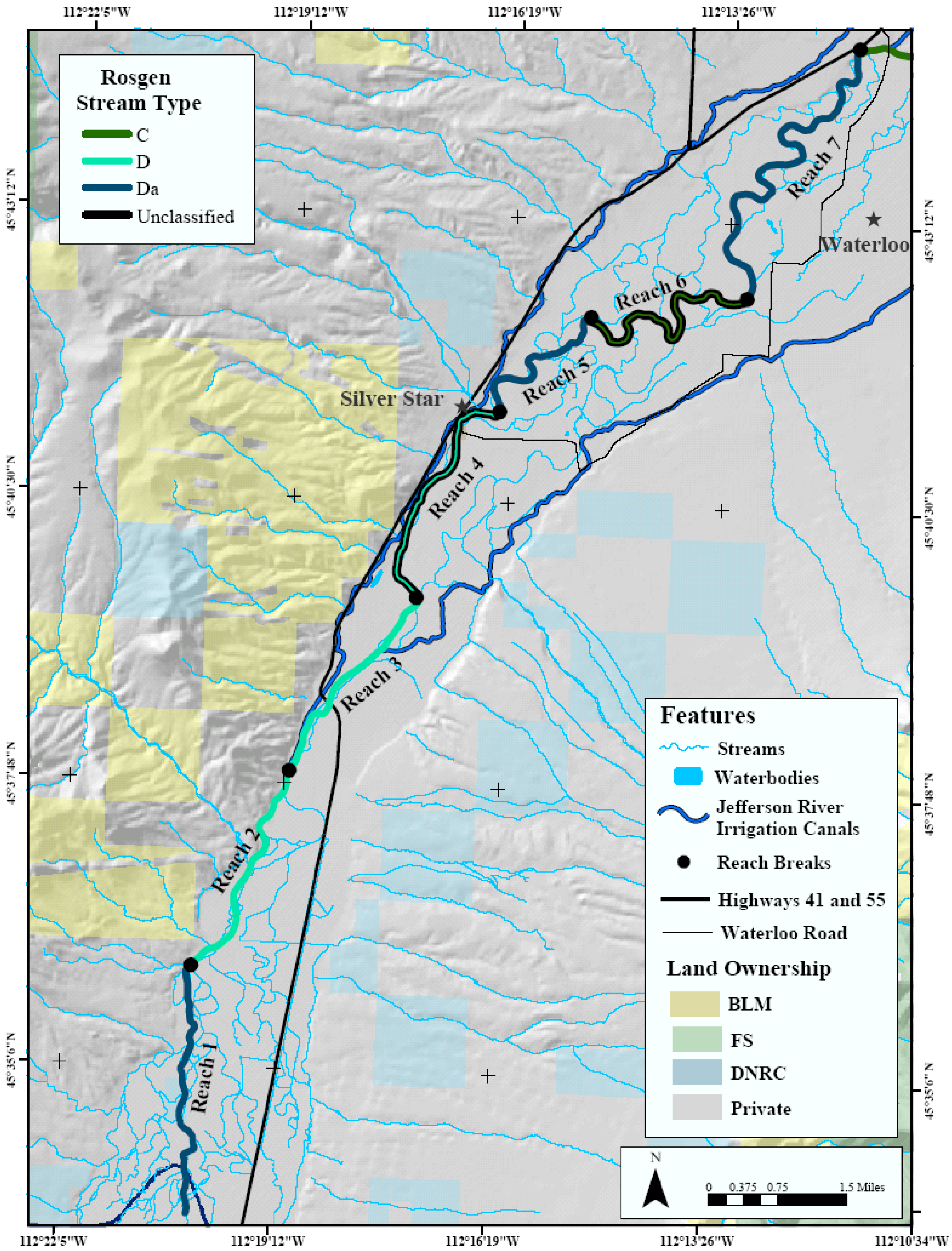

Figure 2-46. Upper Jefferson River Rosgen Stream Type, Reaches 1 to 7

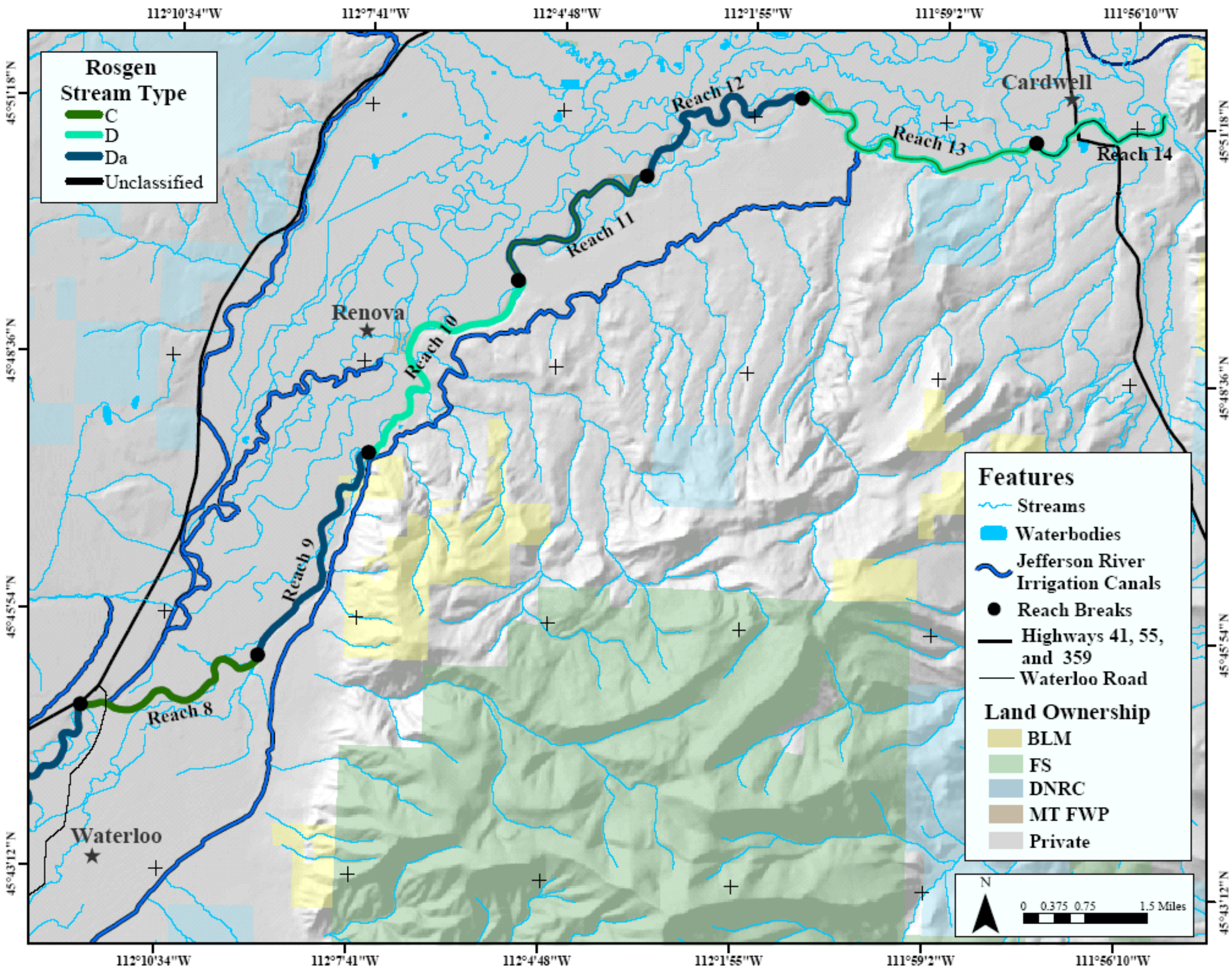

Figure 2-47. Upper Jefferson River Rosgen Stream Type, Reaches 8 to 14

2.2.10.2 Upper Jefferson River Riparian Vegetation

The dominant riparian cover along the Upper Jefferson River is wetland vegetation (**Figures 2-48 and 2-49**). Many types of cottonwoods, willows, shrubs and herbaceous plants were identified during the 2003 riparian inventory (Hoitsma Ecological, 2003). In general, wetland vegetation extended to 100 feet or more along both sides of the main river channel. Buffer widths for the 2002 photos were based on the GIS layer created by Hoistma Ecological, but were measured from the aerial photographs for the 1983 analysis. Differences in riparian buffer widths between 1983 and 2002 should be interpreted with this in mind. Between 1983 and 2001, the riparian buffer width in Reaches 2, 3, and 4 appeared to increase by an average of 12 percent, 28 percent, and 26 percent, respectively. During the same time period, buffer widths appeared to decrease in Reaches 6, 7, and 14 by 25 percent, 57 percent, and 42 percent, respectively.

2.2.10.3 Upper Jefferson River Pollution Sources

Figures 2-50 and **Figure 2-51** display the pollution sources assigned to the upper reaches of the Jefferson River. Aside from visible observations on the aerial photos and information from GIS layers, much of the pollution source information for the Upper Jefferson River for the 2002 analysis was taken from information collected during the 2003 riparian inventory (Hoitsma Ecological, 2003). The source of impacts from abandoned mine lands was taken from GIS layers which located abandoned mines up tributary drainages which eventually drain to reaches of the Upper Jefferson River.

This GIS identified source was not field verified, and results of the 2004 metals monitoring revealed no water quality violations for copper and lead in this section of the Jefferson River. Many pollution sources observed along the Upper Jefferson River were related to agricultural operations (irrigated agriculture, water diversions, loss of riparian habitat). All of the reaches assigned for the source of streambank modifications/destabilization were done so on the basis of information collected during the 2003 riparian inventory, and represent rip-rap, eroding banks, and impaired banks. The most notable difference in sources between 1983 and 2002 was the effect of drought.

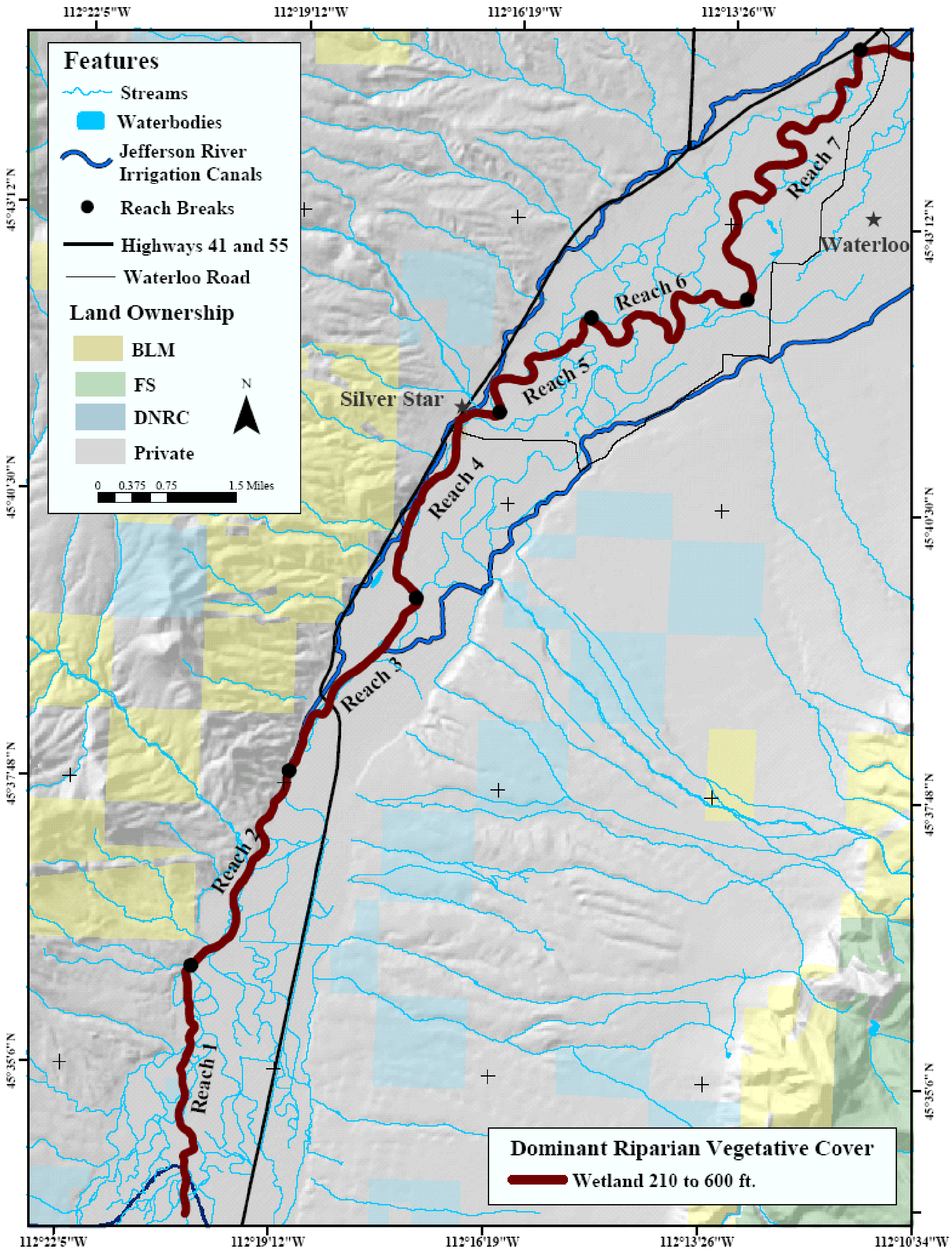

Figure 2-48. Upper Jefferson River Riparian Vegetation, Reaches 1 to 7

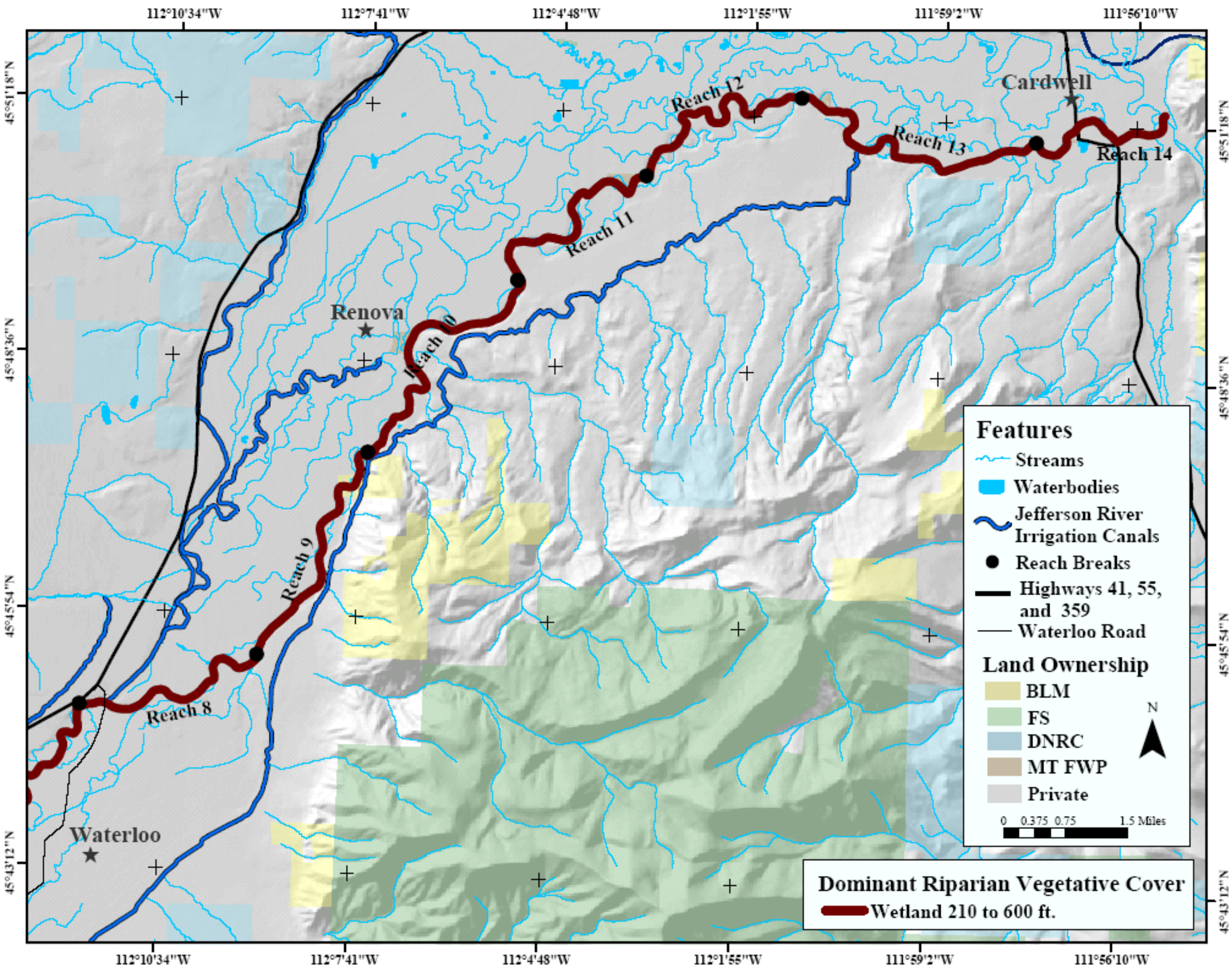

Figure 2-49. Upper Jefferson River Riparian Vegetation, Reaches 8 to 14

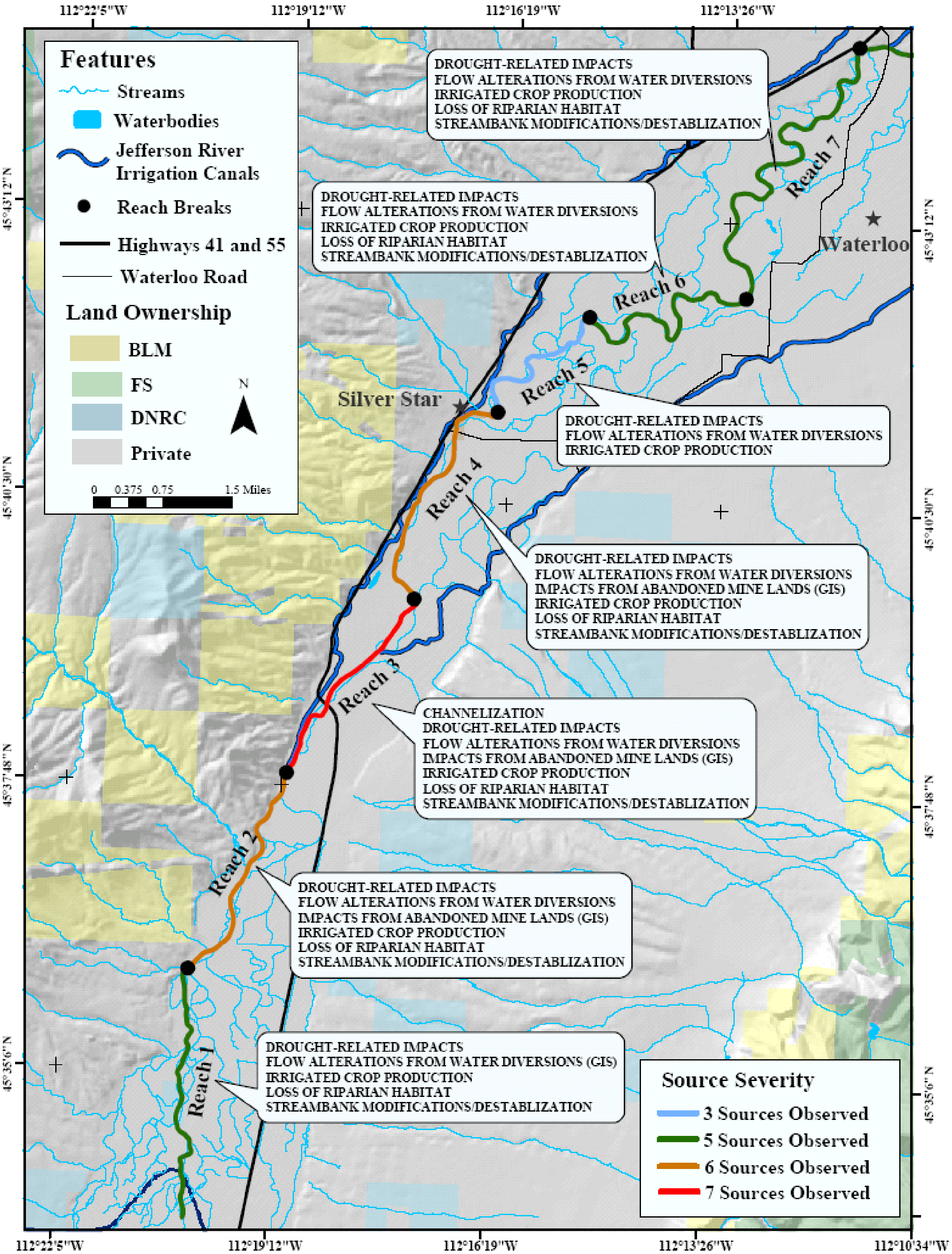

Figure 2-50. Upper Jefferson River Pollution Sources, Reaches 1 to 7

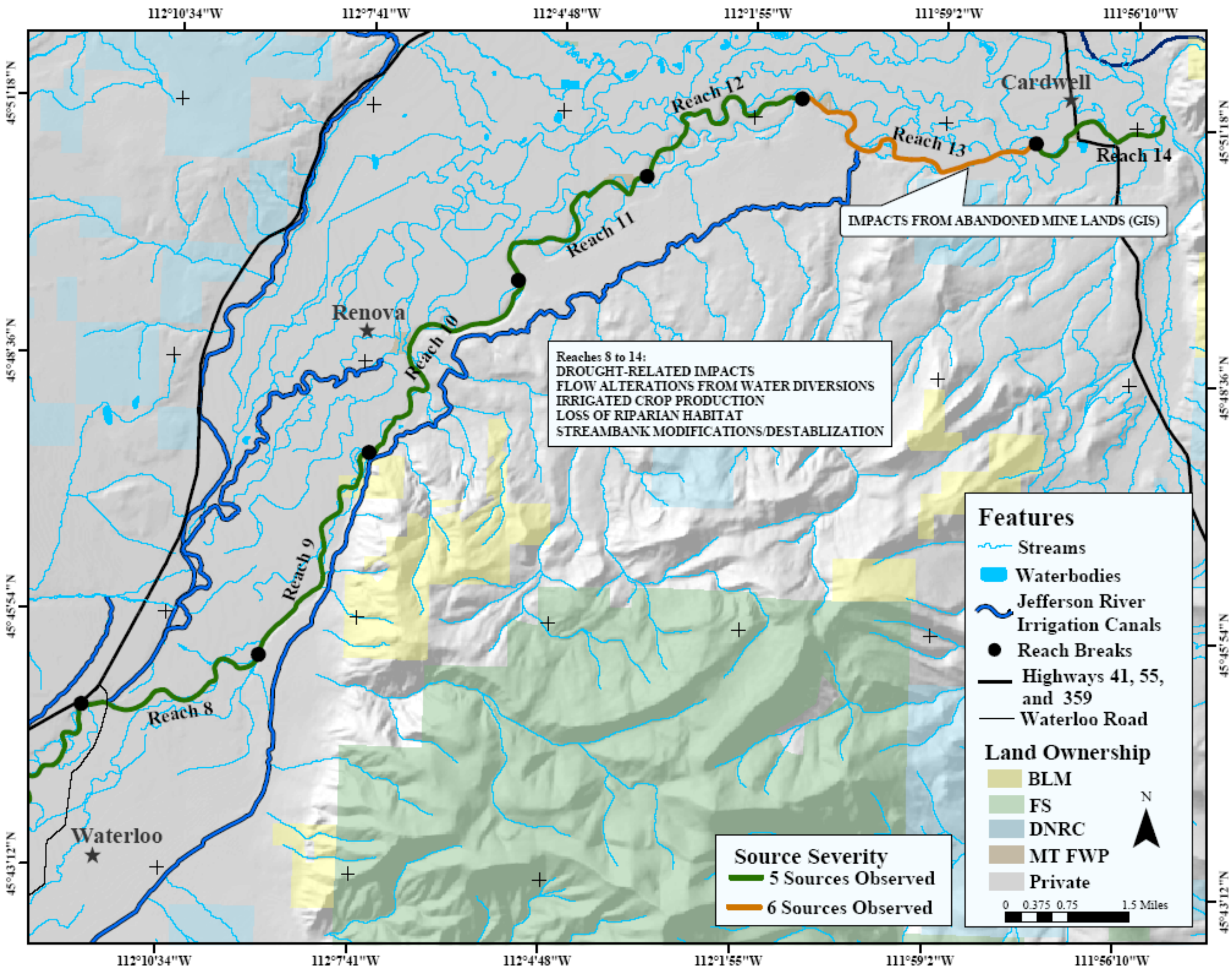

Figure 2-51. Upper Jefferson River Pollution Sources, Reaches 8 to 14

3.0 UPPER JEFFERSON SOURCE ASSESSMENT CONCLUSIONS

Overall, the most ubiquitous source affecting the 303(d) Listed tributary streams in the Upper Jefferson Watershed is riparian grazing. In many instances poor grazing practices have led to degraded riparian areas, unstable stream banks, and increased delivery rates of sediment, and possibly nutrients and pathogens to the listed streams. Roads would be the next most prevalent source to the tributary streams; delivering sediment, affecting buffer widths of riparian vegetation, and causing channel alterations. Natural sources of pollution in the Upper Jefferson Watershed can exacerbate problems stemming from anthropogenic sources. This is particularly true in the case of the highly erosive granitic geology, the Boulder Batholith (TKb), that is found along some portion of all of the 303(d) Listed tributary streams except for Fitz Creek and Dry Boulder Creek. The TKb formation is composed primarily of quartz monzonite and produces coarse sands that are easily transported during runoff events. The TKb formation appears to create a pattern of excessive coarse sediment deposition. In general, the listed streams found in this geology have high sediment loads, especially bed load.

Flow alterations from water diversions, and irrigated agriculture, are prominent in the Jefferson Valley, along the major tributary streams and the Upper Jefferson River. In some cases, water loss from a stream system is detrimental, and separating the effect of flow alterations from drought impacts may prove to be a difficult task, particularly in the case of the Jefferson River. In other cases, water additions may be damaging. For instance, although irrigation return flows add water back to stream systems, the water quality may be poor due to the addition of contaminants such as sediment, nutrients, heat, and possibly pesticides and herbicides.

3.1 Big Pipestone Creek

Data results from the 2004 source assessment have provided support for the following 303(d) Listed, suspected causes of impairment to Big Pipestone Creek: bank erosion, channel incisement, habitat degradation/alteration, riparian degradation, suspended sediment, and thermal modifications. Results from the 2004 water quality monitoring project provide support for impairment from nutrients. Spatially, the sources of hydromodification from Delmoe Lake releases (causing habitat alteration and probably disrupting suspended sediment loading) and unpaved road/trail sediment sources are particularly prominent in Reaches 1 to 8. At Reach 9, the first major irrigation diversions occur with hydromodification from irrigation diversions continuing virtually to the mouth of the stream. Bank erosion, channel incisement, riparian degradation, and grazing related sources were observed in almost all of the valley reaches surveyed in the field. Most likely, siltation is a cause of impairment for Reaches 10 to 16. Channelization is a particular problem for Reach 14, and the related headcutting effect may extend downstream of the reach. Municipal point source pollution most likely enters in Reach 16 from the Whitehall sewage lagoons. Sources associated with silviculture were not observed, although during the field source assessment a notice for a pending timber sale near the base of Delmoe Lake was posted. One source associated with thermal modifications was observed at the site of Pipestone Hot Springs (Reach 12), but this is most likely a natural thermal input. Source allocation work will need to be completed to quantify loadings from the pollutant source areas.

3.2 Cherry Creek

Data results from the 2004 source assessment did not provide direct support for the 1996 303(d) Listed suspected cause of impairment to Cherry Creek: flow alteration. Grazing related impacts were observed in Reaches 2 and 3, but do not necessarily represent impairment to beneficial uses. A report from a landowner at the base of the alluvial fan to Roxann Lincoln of the Jefferson River Watershed Council indicated that the stream usually goes dry there during the irrigation season. The stream appeared fairly healthy where surveyed in Reach 6, and was one of the few sites observed in the field with regenerating cottonwoods. Based on the visual results from the aerial assessment, possible negative impacts associated with flow alteration would most likely be located in Reaches 5 and 6, where irrigation diversions were observed.

3.3 Dry Boulder Creek

Data results from the 2004 source assessment did not provide direct support for the 1996 303(d) Listed suspected causes of impairment to Dry Boulder Creek: flow alteration and siltation. The stream was observed going dry in Reach 3, which corresponded with the reach where the Coal Creek diversion is, but the diversion site was not seen directly. With the name Dry Boulder Creek, and given the arid environment, it is very likely that this stream would naturally go dry on the alluvial fan. The change in lithology from crystalline rocks to porous carbonate rocks in Reach 3 may also contribute to natural stream dewatering. Siltation did not appear to be a problem where the creek was observed in Reaches 1 and 2. The Lower Boulder Lake water was crystal clear, and no excessive fines were observed in Reach 2. A stream ford observed in Reach 3, where there was still water in the stream, did not appear to contribute much silt. The only observed sediment source in need of correction was at the fist road crossing at the end of Reach 3. A large area of the unpaved public road is draining to the creek during wet events. The creek was dry at this point, and road fines were tracked at a few hundred feet downstream in the channel. Agriculture sources were not observed in the field or during the aerial assessment. During the aerial inventory, some stream modifications associated with past mining operations were observed in Reach 1, but the downstream impacts were not witnessed in the field.

3.4 Fish Creek

Data results from the 2004 source assessment may provide support for the following 303(d) Listed suspected causes of impairment to Fish Creek: habitat alterations, siltation, and flow alteration. Results from the 2004 water quality monitoring did not provide support for impairment from cadmium. Spatially, the sources of abandoned mines/resource extraction were observed in the field and aerially in Reaches 1 to 4. Channelization of a portion of Reach 3 was observed. The effects of placer mining and channelization in these reaches have caused modifications to channel form and alterations to riparian vegetation. Lack of cadmium water quality violations during the 2004 water sampling indicate that acid mine drainage is probably not occurring. Grazing sources were observed in Reaches 3 and 6 where destabilized stream banks have resulted in sediment delivery to the stream. Road sediment delivery sites were observed in Reaches 5, 7, 8, and 14. Sands were prominent in the streambed in Reaches 6, 14 and 15, but this is typical of streams in granitic geology. During the aerial inventory, agricultural operations were observed in Reaches 14 to 17. Discussions with a landowner in Reach 14

revealed that a water right held by the City of Butte diverts most of the creek's flow out of the watershed to the Basin Creek Reservoir. The diversion is located in the upper headwaters and was not located in the field. Butte's diversion diverts flow year round, and only needs to keep enough water in the stream for the senior water right holder located in Reach 16. The creek is usually dry below Reach 17. Reach 18 is channelized in areas and is part of the Jefferson Valley irrigation canal system. Due to the upstream water diversions and inflow from two different canals in Reach 17, it is likely that water in Reach 18 is Jefferson River water. As TMDLs are only required for pollutants, work is needed to quantify the effect of sediment on beneficial uses in Fish Creek. This effort should likely focus on reaches that support trout habitat.

3.5 Fitz Creek

Data results from the 2004 source assessment did not provide direct support for the 1996 303(d) Listed suspected cause of impairment to Fitz Creek: siltation. However, the stream was only observed in the field for a small section where it held water and for most of the alluvial fan where it was dry. Grazing was observed in Reaches 4 and 5, but appeared to have minimal impact due to lack of water in the stream. A stream ford was observed in Reach 4 which was a probably, overall, a minor sediment source to the stream. A small section of the road that follows the stream course was viewed in Reach 4. Although the road was within 100 feet of the stream, the riparian buffer and small active channel width appeared minimally affected by road sediment input. Depending on the results of the DEQ's reassessment monitoring, private property access may be needed to view the stream above the alluvial fan and quantify the effects of sediment on beneficial uses in Fitz Creek.

3.6 Halfway Creek

Data results from the 2004 source assessment may provide support for the following 303(d) Listed suspected causes of impairment to Halfway Creek: habitat alterations and siltation. Grazing sources were observed in Reaches 6 and 7 where destabilized stream banks have resulted in sediment delivery to the stream. Road sediment delivery sites and riparian disturbance were also observed in Reaches 6 and 7, but appeared to be more problematic in Reach 7. Sands were prominent in the streambed, as is typical of streams in granitic geology, but siltation was also evident, particularly in Reach 7. Although the upper reaches were not viewed in the field, it is thought that siltation impacts may not be problematic until Reaches 6 and 7 where roads and unpaved trails provide easy access to the stream and riparian area. As TMDLs are only required for pollutants, work is needed to quantify the effect of sediment on beneficial uses in Halfway Creek. This effort should likely focus on reaches that support trout habitat, and where road and grazing sources are present.

3.7 Hells Canyon Creek

Data results from the 2004 source assessment on Hells Canyon Creek may provide support for the 303(d) Listed suspected causes of impairments for habitat alterations and siltation, but did not provide direct support for dewatering/flow alteration. Grazing sources were observed in Reaches 4 and 6, where destabilized stream banks have resulted in sediment delivery to the stream. Part of Reach 4 is within the Hell's Canyon Creek Riparian Project area and is fenced off

from grazing. There was a significant difference in vegetative health and stream bank condition outside of the riparian project area. Road sediment delivery sites and riparian disturbance were observed in Reaches 3, 4, 5 and 6. Road sediment delivery in Reach 5 is most problematic due to a catastrophic road failure that occurred sometime between 1983 and 2001. Although the area is closed to car traffic, ATV traffic is still allowed. Sands were prominent in the streambed, as is typical of streams in granitic geology, but siltation was also evident in Reaches 4, 5, 6, and 9. Sources associated with hydromodification were not visually observed in the field or on the aerial photos. Silviculture harvest was observed on the photos and was noted as occurring sometime before 1983. As TMDLs are only required for pollutants, work is needed to quantify the effect of sediment on beneficial uses in Halfway Creek. This effort should likely focus on reaches that support trout habitat, and where road and grazing sources are present.

3.8 Little Pipestone Creek

Data results from the 2004 source assessment have provided support for the following 303(d) Listed suspected causes of impairment to Little Pipestone Creek: bank erosion, habitat alteration, riparian degradation, and siltation. Channelization is particularly problematic for Reaches 2 and 3, and has resulted in alteration of channel form and infringement on the riparian area. Grazing impacts resulting in bank erosion and riparian degradation were observed in Reaches 1 and 10. Riparian buffer widths were minimal in Reaches 4, 5, 9, and 10. Agricultural operations were aerially observed in Reaches 4, 5, 8, 9, and 10. At Reach 9, the first major irrigation diversion was visually observed on the aerial photos. During the field source assessment of Reach 10, stream flow was less than a third of what it was observed at in Reach 8, and eventually went dry before the end of the reach area surveyed. Bank erosion, channel incisement, riparian degradation, and grazing related sources were observed in the valley reaches surveyed in the field. Sands were prominent in the streambed, as is typical of streams in granitic geology, but siltation was also evident in Reaches 8 and 10. Source allocation work will need to be completed to quantify loadings from the pollutant source areas.

3.9 Whitetail Creek

Data results from the 2004 source assessment have provided support for the following 303(d) Listed suspected causes of impairment to Whitetail Creek: dewatering/flow alterations, habitat alterations, riparian degradation, and siltation. Results from the 2004 water quality monitoring project may also provide support for impairment from nutrients. Dewatering appeared problematic during the 2004 water quality monitoring in Reach 17, as the stream went dry in August. The Whitetail Canal diversion diverts in Reach 16, so that dewatering probably begins here during the irrigation season. A large diversion was also observed in Reach 14, but some flow remained in the creek throughout the 2004 sampling in this reach. The effects of flow releases from Whitetail Reservoir are unknown, but likely disrupt suspended sediment transport and may have altered channel form in the upper reaches. Stream conditions were better on the surveyed portions of Upper Whitetail Creek below Whitetail Reservoir, in comparison to areas of Big Pipestone Creek surveyed below Delmoe Lake. Grazing related sources were observed in Reach 5, but may not necessarily represent impairment to beneficial uses. Stream condition takes a turn for the worse in Reach 13. Excess silt, areas of bank erosion, channel incisement, riparian degradation, and grazing related sources were field observed in portions of Reaches 13, 14, 16,

and 17. Source allocation work will need to be completed to quantify loadings from the pollutant source areas. Source allocation efforts should probably focus on Reaches 13 to 17.

3.10 Upper Jefferson River

Data results from the 2004 source assessment of the Upper Jefferson River may provide support for the 303(d) Listed suspected causes of impairments for dewatering/flow alterations, habitat alterations, suspended sediment/siltation, and thermal modifications. Results of the 2004 water quality monitoring appeared to challenge the 303(d) Listing for impairment from copper and lead. However, extremely low field measurements of dissolved oxygen during the 2004 monitoring raised questions about nutrient impairments to the river. Irrigated agriculture and associated flow diversions and return flow canals were observed along most of the Upper Jefferson River. It is likely that any impairment from dewatering/flow alterations, habitat alterations, and thermal modifications are associated with water withdrawals, water returns, and possibly field conversion of riparian area. Channel braiding was common along the river, and appeared to increase in areas between 1983 and 2002. The increase in the appearance of gravel bars is thought to be related to drought versus an increase in sediment supply; yet this aerial observation should be quantified in the field. Visual observations from the 2003 riparian inventory indicated that “limited fine sediment” was present in areas of low velocity, and that “the channel bed was consistently comprised of cobble and gravel” (Hoistma, Inc., p. 18). As TMDLs are only required for pollutants, work is needed to quantify the effects on beneficial uses and potentially allocate loads for sediment, nutrients, and temperature in the Upper Jefferson River.

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APPENDIX D
UPLAND USLE BASED SEDIMENT MODEL, SEDIMENT CONTRIBUTION FROM HILLSLOPE EROSION FOR TRIBUTAIRES OF THE UPPER JEFFERSON TMDL PLANNING AREA

Introduction

Upland sediment loading due to hillslope erosion was modeled using the Universal Soil Loss Equation (USLE) and sediment delivery to the stream was predicted using a sediment delivery ratio. This model provided an assessment of existing sediment loading from upland sources and an assessment of potential sediment loading through the application of Best Management Practices (BMPs). For this evaluation, the primary BMP evaluated includes the modification in upland management practices. When reviewing the results of the upland sediment load model it is important to note that a significant portion of the remaining sediment loads after BMPs in areas with grazing and/or silvicultural land-uses is also a component of the “natural upland load”. However, the assessment methodology didn’t differentiate between sediment loads with all reasonable BMPs and “natural” loads.

A list of land cover classifications used in the USLE model is presented in **Table D-1**, along with a description of which land-use was associated with each cover type for the purposes of sediment source assessment and load allocations.

Table D - 1. Land Cover Classifications for the USLE Model.

Land Cover Classifications	Land-use / Sediment Source
Bare Rock/Sand/Clay	Natural Sources
Deciduous Forest	Natural Sources
Evergreen Forest	Natural Sources
Mixed Forest	Natural Sources
Grasslands/Herbaceous	Grazing
Emergent Herbaceous Wetlands	Natural Sources
Logging	Silviculture
Pasture/Hay	Cropland
Shrubland	Grazing
Small Grains	Cropland
Woody Wetlands	Natural Sources

Universal Soil Loss Equation (USLE)

The general form of the USLE has been widely used for erosion prediction in the U.S. and is presented in the National Engineering Handbook (1983) as:

(1) A = RK(LS)CP (in tons acre-1 year-1)

where soil loss (A) is a function of the rainfall erosivity index (R), soil erodibility factor (K), overland flow slope and length (LS), crop management factor (C), and conservation practice factor (P) (Wischmeier and Smith 1978, Renard et al. 1991). USLE was selected for the Jefferson River Watershed due to its relative simplicity, ease in parameterization, and the fact that it has been integrated into a number of other erosion prediction models. These include: (1) the Agricultural Nonpoint Source Model (AGNPS), (2) Areal Nonpoint Source Watershed Environment Response Simulation Model (ANSWERS), (3) Erosion Productivity Impact Calculator (EPIC), (4) Generalized Watershed Loading Functions (GWLF), and (5) the Soil Water Assessment Tool (SWAT) (Doe, 1999). A detailed description of the general USLE model parameters is presented below.

The **R-factor** is an index that characterizes the effect of raindrop impact and rate of runoff associated with a rainstorm. It is a summation of the individual storm products of the kinetic energy in rainfall (hundreds of ft-tons acre-1 year-1) and the maximum 30-minute rainfall intensity (inches hour-1). The total kinetic energy of a storm is obtained by multiplying the kinetic energy per inch of rainfall by the depth of rainfall during each intensity period.

The **K-factor** or soil erodibility factor indicates the susceptibility of soil to resist erosion. It is a measure of the average soil loss (tons acre-1 hundreds of ft-tons-1 per acre of rainfall intensity) from a particular soil in continuous fallow. The K-factor is based on experimental data from the standard SCS erosion plot that is 72.6 ft long with uniform slope of 9%.

The **LS-factor** is a function of the slope and overland flow length of the eroding slope or cell. For the purpose of computing the LS-value, slope is defined as the average land surface gradient. The flow length refers to the distance between where overland flow originates and runoff reaches a defined channel or depositional zone. According to McCuen, (1998), flow lengths are seldom greater than 400 feet or shorter than 20 feet.

The **C-factor,** or crop management factor, is the ratio of the soil eroded from a specific type of cover to that from a clean-tilled fallow under identical slope and rainfall. It integrates a number of factors that effect erosion including vegetative cover, plant litter, soil surface, and land management. The original C-factor of the USLE was experimentally determined for agricultural crops and has since been modified to include rangeland and forested cover. It is now referred to as the vegetation management factor (VM) for non-agricultural settings (Brooks, 1997).

Three different kinds of effects are considered in determination of the VM-factor. These include: (1) canopy cover effects, (2) effects of low-growing vegetal cover, mulch, and litter, and (3) rooting structure. A set of metrics has been published by the Soil Conservation Service (SCS) for estimation of the VM-factors for grazed and undisturbed woodlands, permanent pasture, rangeland, and idle land. Although these are quite helpful for the Jefferson River setting, Brooks (1997) cautions that more work has been carried out in determining the agriculturally based C-factors than rangeland/forest VM-factors. Because of this, the results of the interpretation should be used with discretion.

The **P-factor** (conservation practice factor) is a function of the interaction of the supporting land management practice and slope. It incorporates the use of erosion control practices, such as strip-

cropping, terracing, and contouring, and is applicable only to agricultural lands. Values of the P-factor compare straight-row (up-slope down-slope) farming practices with that of certain agriculturally-based conservation practices.

Modeling Approach

Sediment delivery from hillslope erosion was estimated using a Universal Soil Loss Equation (USLE) based model to predict soil loss, along with a sediment delivery ratio (SDR) to predict sediment delivered to the stream. This USLE based model is implemented as a watershed scale, grid format, GIS model using ArcView v 9.0 GIS software.

Desired results from the modeling effort include the following: (1) annual sediment load from each of the water quality limited segments on the state's 303(d) list, (2) the mean annual source distribution from each land category type, and (3) annual potential sediment load from each of the water quality limited segments on the state's 303(d) list after the application of upland management BMPs. Based on these considerations, a GIS- modeling approach (USLE) was formulated to facilitate database development and manipulation, provide spatially explicit output, and supply output display for the modeling effort.

Modeling Scenarios

Two upland management scenarios were proposed as part of the Jefferson modeling project. They include: (1) an existing condition scenario that considers the current land use cover and management practices in the watershed and (2) an improved grazing and cover management scenario.

Erosion was differentiated into two source categories for each scenario: (1) natural erosion that occurs on the time scale of geologic processes and (2) anthropogenic erosion that is accelerated by human-caused activity. A similar classification is presented as part of the National Engineering Handbook Chapter 3 - Sedimentation (USDA, 1983). Differentiation is necessary for TMDL planning.

Data Sources

The USLE-3D model was parameterized using a number of published data sources. These include information from: (1) USGS, (2) Spatial Climate Analysis Service (SCAS), and (3) Soil Conservation Service (SCS). Additionally, local information regarding specific land use management and cropping practices was acquired from the Montana Agricultural Extension Service and the Natural Resource Conservation Service (NRCS). Specific GIS coverages used in the modeling effort included the following:

R – Rainfall factor. Grid data of this factor was obtained from the NRCS, and is based on Parameter-elevation Regressions on Independent Slopes Model (PRISM) precipitation data. PRISM precipitation data is derived from weather station precipitation records, interpolated to a gridded landscape coverage by a method (developed by the Spatial Climate Analysis Service of Oregon State University) which accounts for the effects of elevation on precipitation patterns.

K – Soil erodibility factor. Polygon data of this factor were obtained from the NRCS General Soil Map (STATSGO) database. The USLE K factor is a standard component of the STATSGO soil survey. STATSGO soils polygon data were summarized and interpolated to grid format for this analysis.

LS – Slope length and slope factors. These factors were derived from 30m USGS digital elevation model (DEM) grid data, interpolated to a 10m pixel.

C – Cropping factor. This factor was estimated using the National Land Cover Dataset (NLCD), using C-factor interpretations provided by the NRCS and refined by Montana DEQ using SCS C-factor tables (Brooks et al. 1997). C-factors are intended to be conservatively representative of conditions in the Upper Jefferson TPA.

P – Management practices factor. This factor was set to 1, as consultation with the NRCS State Agronomist suggests that this value is the most appropriate representation of current management practices in the Jefferson River watershed (i.e. no use of contour plowing, terracing, etc).

Method

An appropriate grid for each factors' values was created, giving full and appropriate consideration to proper stream network delineation, grid cell resolution, etc. A computer model was built using ArcView Model Builder to derive the five factors from model inputs, multiply the five factors and arrive at a predicted sediment production for each grid cell. The model also derived a sediment delivery ratio for each cell, and reduced the predicted sediment production by that factor to estimate sediment delivered to the stream network.

Specific parameterization of the USLE factors was performed as follows:

Jefferson DEM

The Digital Elevation Model (DEM) for the upper Jefferson watershed (see **Figure 1**) was the foundation for developing the LS factor, for defining the extent of the bounds of the analysis area (the upper Jefferson watershed), and for delineating the area within the outer bounds of the analysis for which the USLE model is not valid (i.e. the concentrated flow channels of the stream network). The USGS 30m DEM (level 2) for the Jefferson was used for these analyses. First the DEM was interpolated to a 10m analytic grid cell to render the delineated stream network more representative of the actual size of Jefferson watershed streams and to minimize resolution dependent stream network anomalies. The resulting interpolated 10m was then subjected to standard hydrologic preprocessing, including the filling of sinks to create a positive drainage condition for all areas of the watershed.

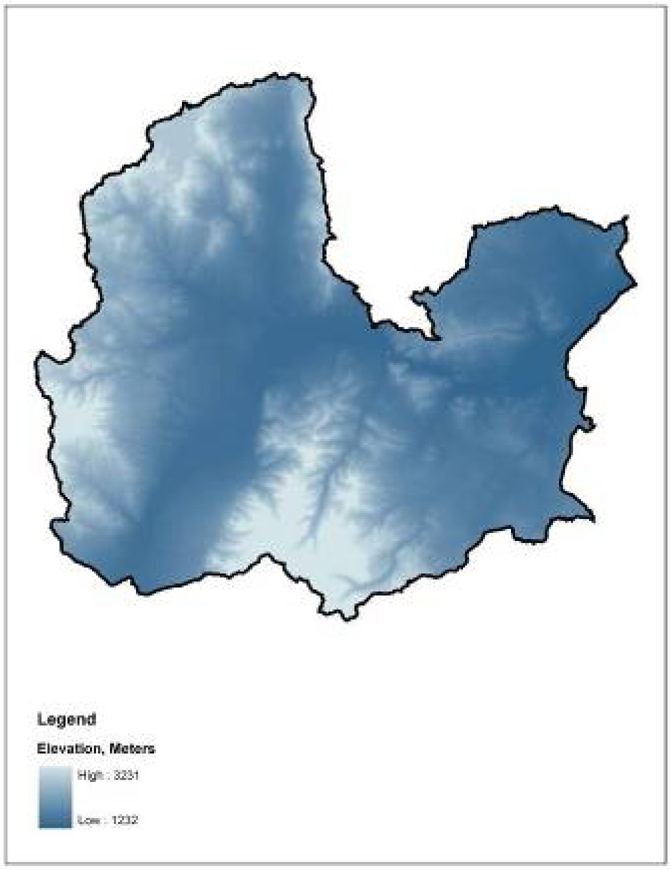

Figure 1 –Digital Elevation Model (DEM) of the Upper Jefferson Watershed, Prepared for Hydrologic Analysis

R-Factor

The rainfall and runoff factor grid was prepared by the Spatial Climate Analysis Service of Oregon State University, at 4 km grid cell resolution (see **Figure 2**). For the purposes of this analysis, the SCAS R-factor grid was reprojected to Montana State Plane Coordinates (NAD83, meters), resampled to a 10m analytic cell size and clipped to the extent of the upper Jefferson watershed, to match the project's standard grid definition.

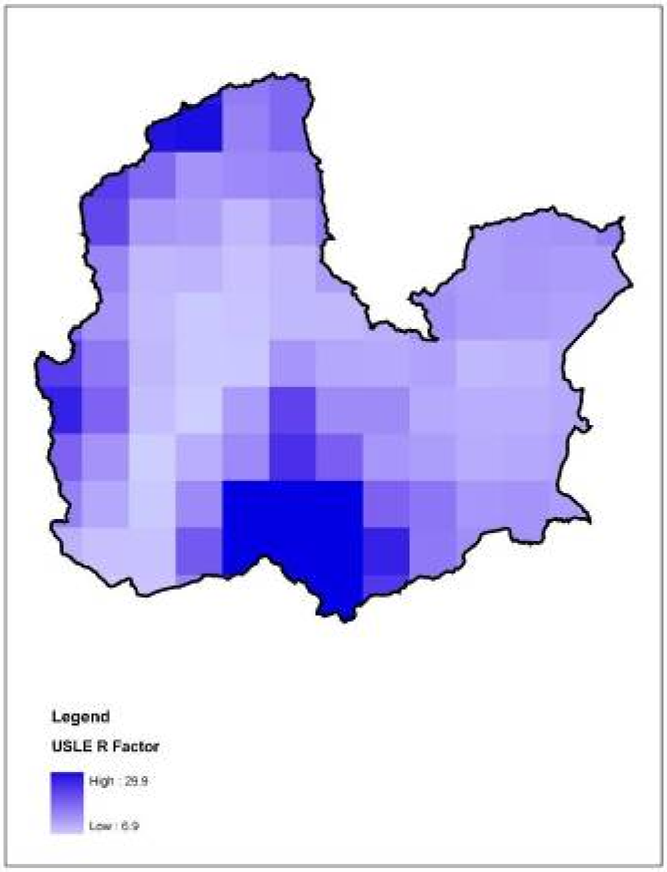

Figure 2 – ULSE R factor for the Upper Jefferson Watershed

K-Factor

The soil erodibility factor grid was compiled from 1:250K STATSGO data, as published by the NRCS (see **Figure 3**). STATSGO database tables were queried to calculate a component weighted K value for all surface layers, which was then summarized by individual map unit. The map unit K values were then joined to a GIS polygon coverage of the STATSGO map units, and the polygon coverage was converted to a 10m analytic grid for use in this analysis.

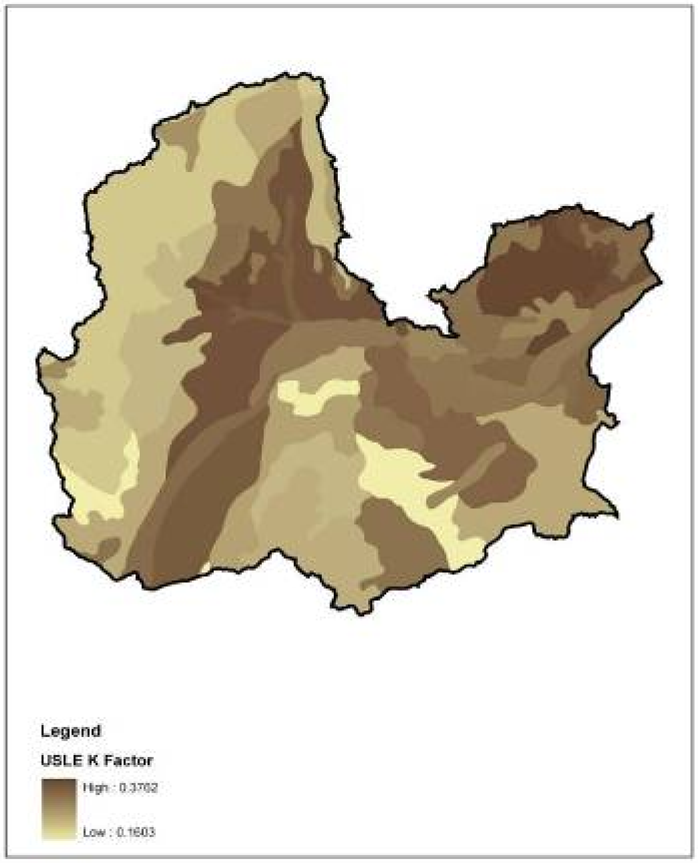

Figure 3 – ULSE K factor for the Upper Jefferson Watershed

LS- Factor

The equation used for calculating the slope length and slope factor was that given in the updated definition of USLE, as published in USDA handbook #537:

$LS = (\lambda/72.6)^m (65.41 \sin^2\theta + 4.56 \sin\theta + 0.065)$

Where:

λ = slope length in feet. This value was determined by applying GIS based surface analysis procedures to the Jefferson watershed DEM, calculating total upslope length for each 10m grid cell, and converting the results to feet from meters. In accordance with research that indicates that, in practice, the slope length rarely exceeds 400 ft, λ was limited to that maximum value.

θ = cell slope cell slope as calculated by GIS based surface analysis procedures from the Jefferson watershed DEM

m = 0.5 if percent slope of the cell >= 5
= 0.4 if percent slope of the cell >= 3.5 AND < 5
= 0.3 if percent slope of the cell >= 1 AND < 3.5
= 0.2 if percent slope of the cell < 1

The LS factor grid was calculated from individual grids computed for each of these sub factors, using a simple ArcView Model Builder script.

C-Factor

The cover management factor of the USLE reflects the varying degree of erosion protection that results from different cover types. It integrates a number of factors including vegetative cover, plant litter, soil surface, and land management. For the purpose of this study, the C-factor is the only USLE parameter that can be altered by the influence of human activity. Based on this, C-factors were estimated for the existing condition and improved management scenarios (**Table D-2**). The C-factor change for agricultural cover types between management scenarios corresponds to increases in the percent of land cover that are achievable through the application of various best management practices (**Table D-3**). For natural sources (i.e. bare rock, deciduous forest, and evergreen forest), the C-factor is the same for both scenarios. A C-factor slightly higher than deciduous/evergreen forest was used for logged areas because logging intensity within the watershed is low and because practices, such as riparian clearcutting, that tend to produce high sediment yields have not been used since at least 1991, when the MT Streamside Management Zone (SMZ) law was enacted. Additionally, the USLE model is intended to reflect long-term average sediment yield, and while a sediment pulse typically occurs in the first year after logging, sediment production after the first year rapidly declines (Rice et al. 1972; Elliot and Robichaud 2001; Elliot 2006). The logging C-factor is the same for both management scenarios to indicate that logging will continue sporadically on public and private land within the watershed and will produce sediment at a rate slightly higher than an undisturbed forest. This is not intended to imply that additional best management practices beyond those in the SMZ law should not be used for logging activities.

C-factors were defined spatially through use of a modified version of the Anderson land cover classification (1976) and the 1992 30m Landsat Thematic Mapper (TM) multi-spectral imaging (NLDC, 1992) (Figure-4). C-factor values were assigned globally to each land type and range from 0.001 to 1.0. These data were reprojected to Montana State plane projection/coordinate system, and resampled to the standard 10m grid. No field efforts were initiated as part of this study to refine C-factor estimation for the watershed.

Table D – 2. Jefferson River C-Factor; Existing Conditions

USLE C-Factor Parameter		C-factor	
Code	**Description**	**Existing Condition**	**Improved Management Condition**
41	Decidous Forest	0.003	0.003
42	Evergreen Forest	0.003	0.003
43	Mixed Forest	0.003	0.003
51	Shrubland	0.046	0.031
71	Grassland/Herbaceous	0.042	0.035
81	Pasture/Hay	0.020	0.013
83	Small Grains	0.240	0.015
84	Fallow	0.440	0.120
N/A	Logging	0.006	0.006

Table D - 3. Changes in percent ground cover for agricultural land cover types between existing and improved management conditions.

Land Cover	Existing % ground cover	Improved % ground cover
Shrubland	55	65
Grasslands Herbaceous	55	65
Pasture /Hay	65	75
Small Grains	20	40
Fallow	5	35

NLDC – Landcover

In general, the land use classification of the NLCD was accepted as is, without ground truthing of original results or correction of changes over the time since the NLCD image was taken (see **Figure 4**). Given that we are looking for watershed and subwatershed scale effects, this was considered to be a reasonable assumption, given the relative simplicity of the land use mix in the Jefferson valley, and the relative stability of that landuse over the 14 years since the Landsat image that the NLCD is based on was shot. One adjustment was made to the NLCD, however. That adjustment was to quantify the amount of logging that has occurred since 1992, and to also identify areas that are reforesting over that same period. As with other land uses in the valley, logging is a stable land use, but it is a land use that causes a land cover change that may effect sediment production.

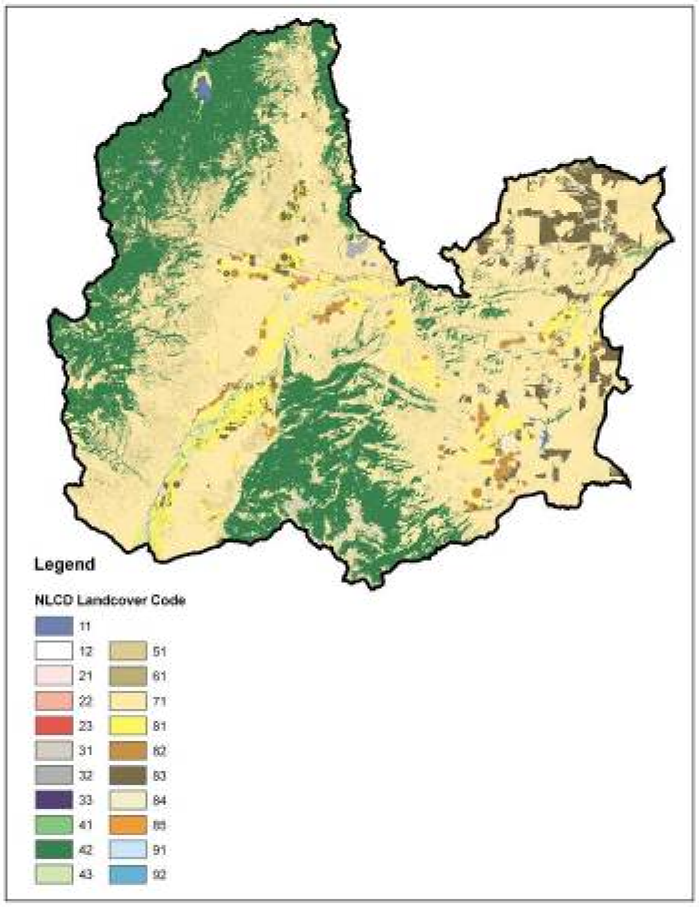

Figure 4 – NLCD Landcover for the Upper Jefferson Watershed

Adjustment for logging and reforestation was accomplished by comparing the 1992 NLCD grid for the upper Jefferson with the 2005 NAIP aerial photography. Areas which were coded as a forest type (41 or 42) on the NLCD were recoded to 'logged' if:

- They appeared to be otherwise (typically bare ground, grassland, or shrubland) on the NAIP photos, and
- There were indications of logging activity (proximity to forest or logging roads, appearance of stands, etc).

Sediment Delivery Ratio

A sediment delivery ratio factor was created for each grid cell, based on the relationship between distance from the delivery point to the stream established by Dube, Megahan & McCalmon in their development of the WARSEM road sediment model for the State of Washington. This relationship was developed by integrating the results of several previous studies (principally those of Megehan and Ketchison) which examined sediment delivery to streams downslope of forest roads. They found that the proportion of sediment production that is ultimately delivered to streams declines with distance from the stream (**Table D-4**) with the balance of the sediment being deposited between the point of production and the stream. We believe the use of this relationship to develop a sediment delivery ratio for a USLE based model is a conservative (i.e.

tending toward the high end of the range of reasonable values) estimate of sediment delivery from hillslope erosion, especially in light of the fact that the USLE methodology does not account for gully erosion. This factor was applied to the results of the USLE model to estimate sediment delivered from hill slope sources, by calculating the distance from each cell to the nearest stream channel, and multiplying the sediment production of that cell by the corresponding distance based percentage of delivery.

Table D – 4 Sediment Delivery vs. Distance

Distance from Culvert (ft)	Percent of Total Eroded Sediment Delivered
0	100
35	70
70	50
105	35
140	25
175	18
210	10
245	4
280	3
315	2
350	1

Results

Figures 5 and **6** present the USLE based hillslope model’s prediction of existing and potential conditions graphically for the entire Upper Jefferson TMDL Planning Area (TPA). **Table D - 5** presents the prediction of existing and potential conditions numerically by landcover type, broken out by sub-watershed for all 303(d) listed tributaries within the Upper Jefferson TPA.

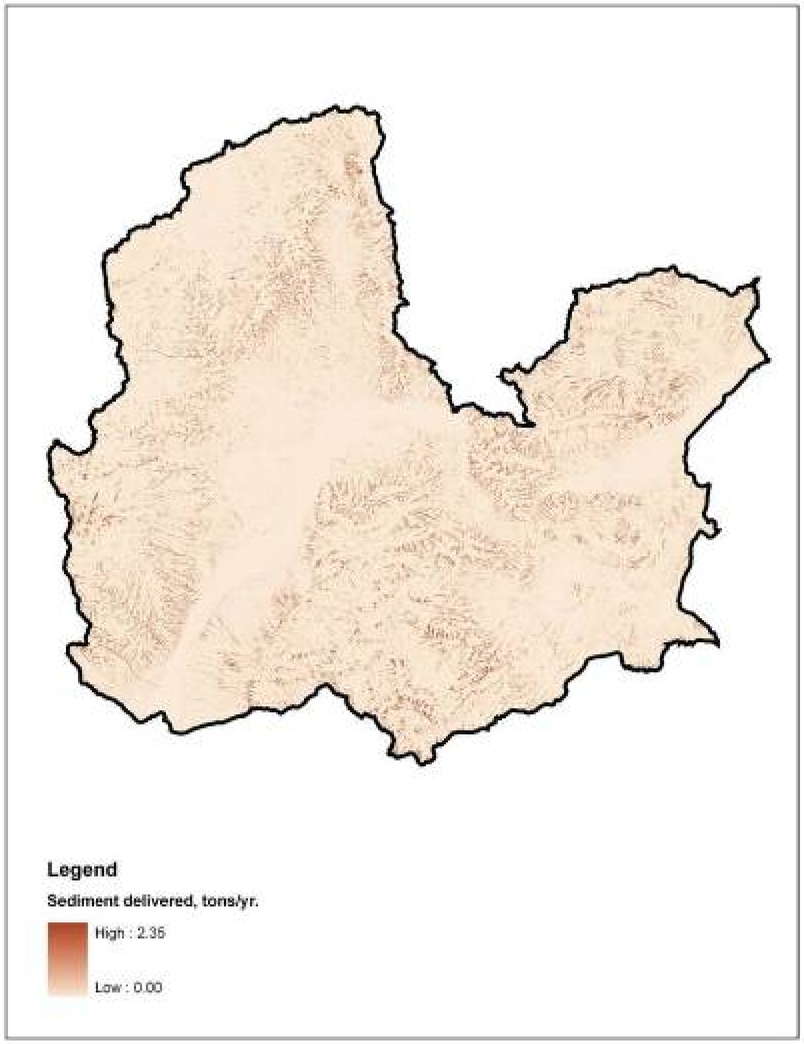

Figure 5 – Predicted Sediment Delivery from Hill Slopes, Existing Condition

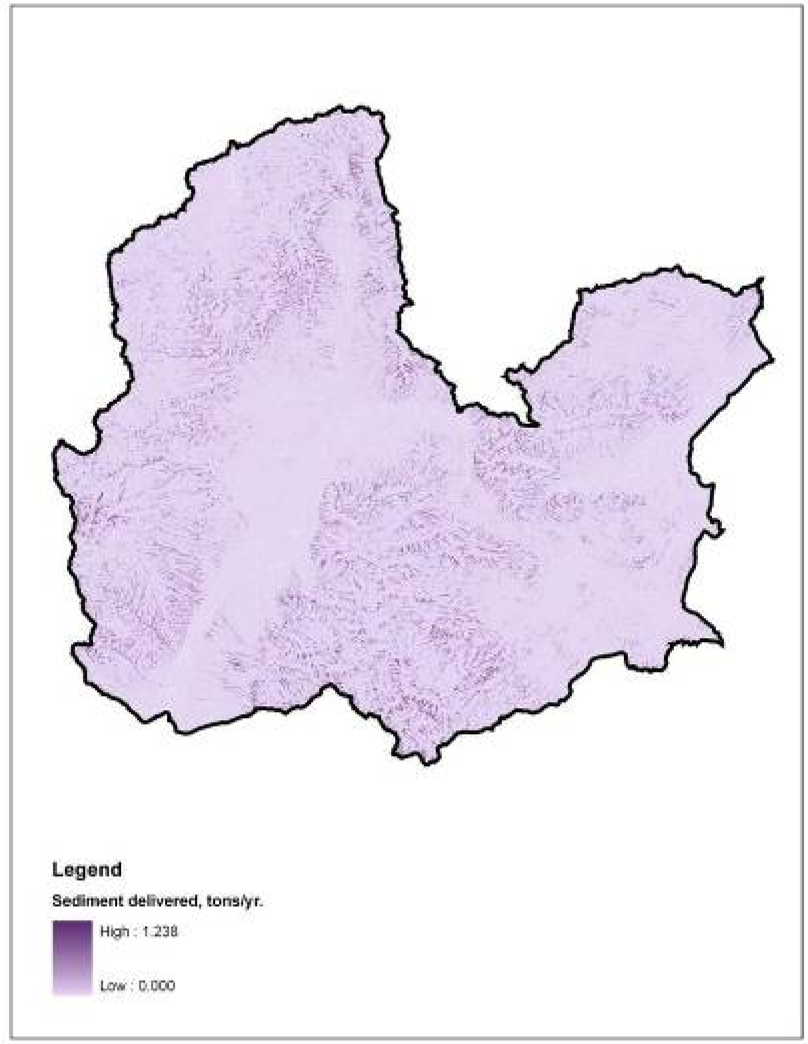

Figure 6 – Predicted Sediment Delivery from Hill Slopes, BMP Conditions

Table D – 5. Existing and Potential Sediment Delivery by 303(d) Listed Tributary (Sub-Watershed) of the Upper Jefferson TPA.

			Upland Sediment Load (tons/yr)	
303(d) Listed Sub-Watershed	Land-use / Sediemtn Source	Existing Landcover Classification	Existing	Potential
Big Pipestone Creek (Halfway Creek and Little Pipestone Creek)	Cropland	Fallow	14.68	4.00
	Cropland	Pasture/Hay	8.40	5.46
	Cropland	Small Grains	57.23	3.60
	Grazing	Grasslands/Herbaceous	1239.19	1032.01
	Grazing	Shrubland	1474.41	993.40
	Natural Sources	Evergreen Forest	495.18	495.18
	Silviculture	Silviculture	4.00	4.00
		Total	**3293.08**	**2537.64**
Cherry Creek	Cropland	Pasture/Hay	0.65	0.42
	Grazing	Grasslands/Herbaceous	256.97	214.14
	Grazing	Shrubland	184.11	124.08
	Natural Sources	Evergreen Forest	33.35	33.35
	Natural Sources	Woody Wetlands	1.10	1.10
		Total	**476.18**	**373.09**
Fish Creek	Cropland	Pasture/Hay	3.95	2.57
	Cropland	Small Grains	1.98	0.12
	Grazing	Grasslands/Herbaceous	591.07	492.45
	Grazing	Shrubland	723.06	487.27
	Natural Sources	Bare Rock/Sand/Clay	1.77	1.77
	Natural Sources	Evergreen Forest	230.41	230.41
	Silviculture	Silviculture	4.00	4.00
		Total	**1556.25**	**1218.59**
Fitz Creek	Cropland	Small Grains	7.93	1.00
	Grazing	Grasslands/Herbaceous	161.58	134.63
	Grazing	Shrubland	74.39	50.13
	Natural Sources	Evergreen Forest	16.00	16.00
		Total	**259.90**	**201.76**
Halfway Creek	Grazing	Grasslands/Herbaceous	34.07	28.39
	Grazing	Shrubland	149.63	100.84
	Natural Sources	Evergreen Forest	51.81	51.81
		Total	**235.50**	**181.03**
Hells Canyon Creek	Grazing	Grasslands/Herbaceous	1001.06	834.21
	Grazing	Shrubland	525.57	354.19
	Natural Sources	Evergreen Forest	126.97	126.97
	Natural Sources	Mixed Forest	2.30	2.30
	Natural Sources	Woody Wetlands	1.06	1.06
		Total	**1656.95**	**1318.72**
Little Pipestone Creek	Cropland	Pasture/Hay	1.11	0.72
	Cropland	Small Grains	1.23	0.08
	Grazing	Grasslands/Herbaceous	438.82	365.68
	Grazing	Shrubland	392.33	264.40
	Natural Sources	Evergreen Forest	113.60	113.60
	Silviculture	Silviculture	0.62	0.62
		Total	**947.71**	**745.10**
Whitetail Creek (Little Whitetail Creek)	Cropland	Pasture/Hay	17.28	11.23
	Cropland	Small Grains	151.70	9.48
	Grazing	Grasslands/Herbaceous	2843.09	2368.90
	Grazing	Shrubland	1810.75	1220.17
	Natural Sources	Emergent Herbaceous Wetlands	1.00	1.00
	Natural Sources	Evergreen Forest	502.00	502.00
	Natural Sources	Woody Wetlands	1.00	1.00
	Silviculture	Silviculture	4.41	4.41
		Total	**5331.23**	**4118.19**

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APPENDIX E
USLE GENERATED UPLAND EROSION CORRECTED FOR EXISTING AND POTENTIAL RIPARIAN HEALTH

Introduction

Upland sediment loading due to hillslope erosion was modeled using the Universal Soil Loss Equation (USLE) and sediment delivery to the stream was predicted using a sediment delivery ratio. The model report and associated output are located in **Appendix D**. This modeling effort did not, however, take into account the effect that vegetated riparian buffers have on reducing the upland sediment load delivered to streams. **Figure E-1** depicts the USLE modeling process without the influence of riparian buffers included. That is, 100 percent of the USLE generated annual sediment load, adjusted via the sediment delivery ratio as defined in **Appendix D**, was delivered to the stream network. Because the modeling process did not account for the sediment reduction efficiency of the vegetated riparian buffer, a secondary effort to qualify and quantify this influence was undertaken and is presented here.

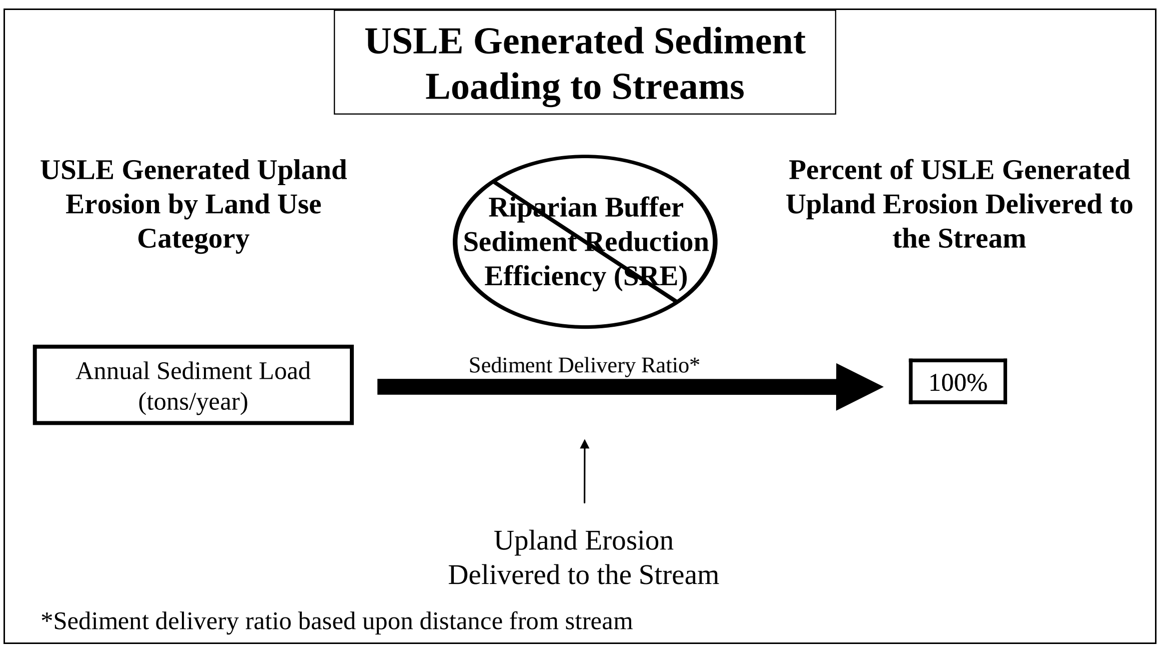


Figure E-1. USLE Upland Sediment Model Excluding the Influence of the Riparian Buffer

The USLE modeling effort (**Appendix D**) estimated existing upland sediment loads and potential reductions in loading associated with the implementation of Best Management Practicies (BMPs). Incorporating a riparian health component improves the estimate of upload loading by routing the modeled existing upland sediment load through the existing riparian buffer condition, routing the modeled reductions associated with upland BMPs through the existing riparian buffer condition, and estimating the overall potential sediment loading reductions associated with routing upland BMP loads through an improved riparian buffer (via BMPs).

Effect of Riparian Buffers on Sediment Loading to Streams

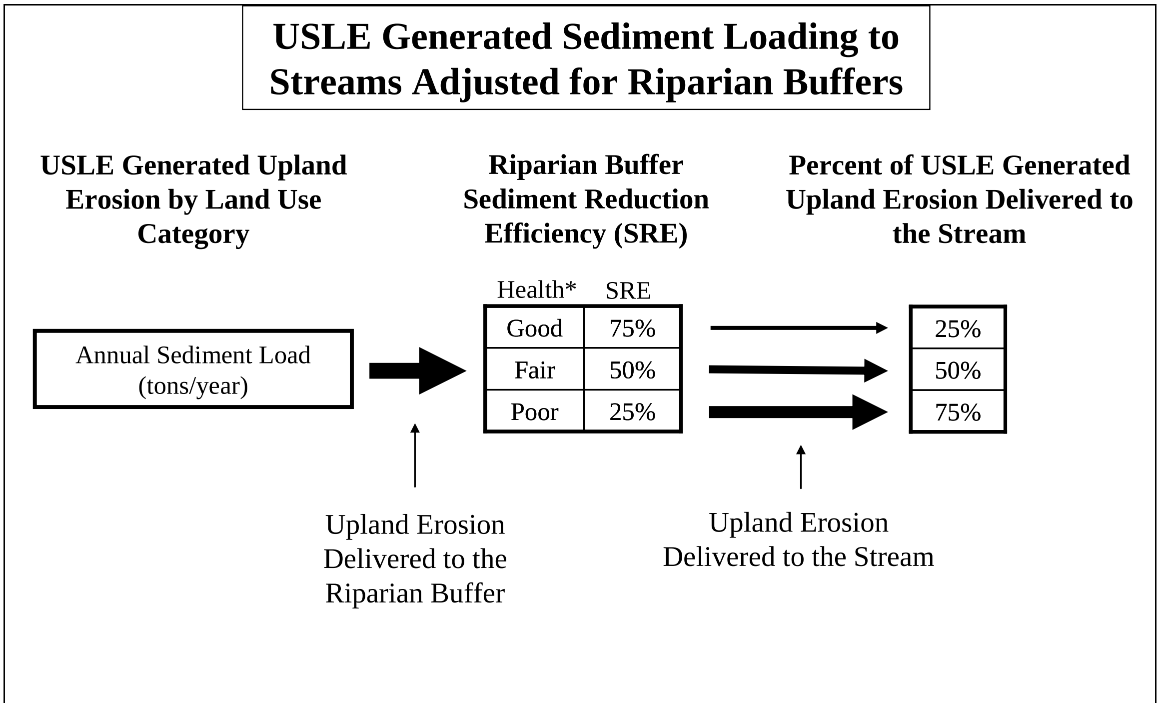
Vegetated riparian buffers function as filters that protect adjoining streams and downstream receiving waters (Martin 1999). Riparian buffers utilize filtration, adsorption, and entrainment to remove sediments, nutrients, and a range of contaminants. Vegetated riparian buffers disperse concentrated or channelized runoff, increasing infiltration, slowing surface runoff, and enhancing the deposition of sediment and sediment associated contaminants from both overland flows and overbank floodwaters (CRWP 2006; Leeds-Harrison 1999; Burt 1999).

Vegetated riparian buffers maintain the connectivity and exchange of surface water and groundwater between rivers and uplands. Maintaining riparian zones and effective land use practices within these zones are widely recognized as two valuable strategies to prevent the degradation of water quality services provided by these essential riparian processes (Hancock, 2002). Because of their ability to reduce upland sources of pollutants, the influence of riparian corridors on water quality is proportionately much greater than the relatively small area in the landscape they occupy.

In general, the effectiveness of vegetated riparian buffers is proportional to their width and overall health. Sediment removal efficiency relationships developed by Castelle and Johnson (2000) estimated near 80 percent sediment removal and 65 percent particulate organic matter removal across a comparable buffer width. Other research in southwest Montana reported greater than 90 percent removal of coarse textured sediment with a six meter buffer on bunchgrass uplands (Hook 2003).

For this analysis, a sediment reduction efficiency of 75 percent was assumed to represent the loading condition for a healthy (Excellent / Good) vegetated riparian buffer. This value reflects those reported in the literature while allowing for some hillslope loading from developed and disturbed land. With 75 percent removal, 25 percent of the USLE generated upland hillslope load is delivered to the stream and assumed to be the natural occurring annual maximum load from upland hillslope erosion. The remaining 75 percent of the load is assumed to be controllable by riparian health and associated buffering capacity.

As the condition of the riparian buffer declines or is degraded, sediment reduction efficiencies of 50 percent and 25 percent are then assumed to represent the loading condition for moderately (Fair) and heavily (Poor) disturbed conditions. That is, as the overall health of the vegetated riparian buffer is degraded, hence reducing its buffering capacity (sediment reduction efficiency), sediment loading delivered to the stream from upland sources increases. With 50 percent and 25 percent removal, 50 percent and 75 percent of the USLE generated upland erosion is delivered to the stream (**Figure E-2**).



*Average health condition of the vegetated riparian buffer

Figure E-2. USLE Upland Sediment Load Adjusted for Riparian Buffer Capacity

Riparian Health

Prior to modeling, a watershed scale riparian health assessment was undertaken to estimate the existing riparian condition of all listed tributary streams within the planning area. This process utilized data and information available within **Appendix C**, Aerial Photo Review and Field Source Assessment. As such, a data set was generated that quantified the existing riparian condition as a percent of the total stream length within each sub-watershed. Riparian health was qualified as Good, Fair or Poor (**Table E-1** and **Figure E-3**). For more information regarding the riparian health assessment see **Appendix C**.

Watershed	Existing Buffer Condition	Stream Length (mi)	Percent of Total Length	Watershed	Existing Buffer Condition	Stream Length (mi)	Percent of Total Length
Big Pipestone Creek	Good	0.0	0	**Halfway Creek**	Good	4.2	55
	Fair	14.6	72		Fair	3.4	45
	Poor	5.7	28		Poor	0.0	0
	Total	20.2	100		Total	7.6	100
Cherry Creek	Good	0.6	9	**Hells Canyon Creek**	Good	4.0	32
	Fair	4.8	70		Fair	7.9	61
	Poor	1.5	21		Poor	0.9	7
	Total	6.9	100		Total	12.8	100
Fish Creek	Good	3.2	14	**Little Pipestone Creek**	Good	1.5	9
	Fair	14.1	62		Fair	4.0	25
	Poor	5.4	24		Poor	10.7	66
	Total	22.7	100		Total	16.2	100
Fitz Creek	Good	0.0	0	**Whitetail Creek**	Good	4.8	21
	Fair	4.8	100		Fair	10.2	44
	Poor	0.0	0		Poor	8.2	35
	Total	4.8	100		Total	23.2	100

Using the information from Big Pipestone Creek as an example:

Along Big Pipestone Creek’s 20.2 miles, the existing health condition of the riparian buffer was defined as consisting of 0.0 miles of Good, 14.6 miles of Fair and 5.7 miles of Poor riparian areas. Thus, the three health categories represent 0, 72 and 28 percent of the total stream length, respectfully (**Table E-1** and **Figure E-3**). This data was then used to evaluate the sediment reduction scenarios presented below.

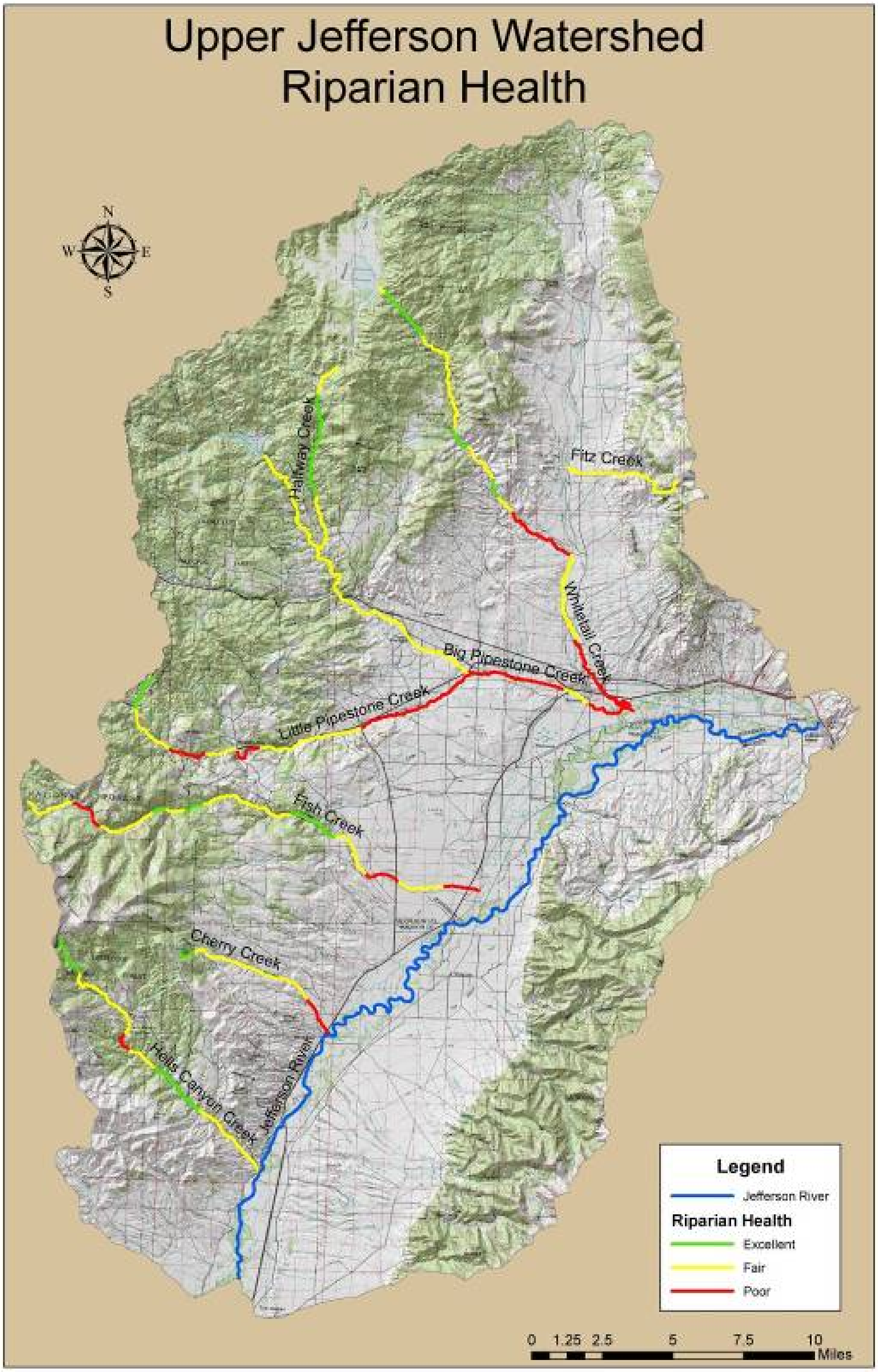


Figure E-3. Upper Jefferson River TMDL Planning Area: Existing Riparian Buffer Condition

Scenario Development

This section outlines the modeling approach that was implemented to evaluate the effect that vegetated riparian buffers have on sediment production and delivery to the stream network within the Upper Jefferson TPA. Results from this effort include the development and assessment of three scenarios:

Scenario 1: Existing Condition
This scenario evaluates the existing condition by routing the existing upland erosion USLE generated sediment load (calculated in **Appendix D**) through the existing condition of the riparian buffer (**Table E-1**). The results of this scenario then represent the existing upland sediment load delivered to the stream.

Scenario 2: Upland BMP Scenario
This scenario evaluates how the application of BMPs on upland land uses can reduce the sediment loading to the stream. For this scenario, the upland erosion USLE generated BMP load (calculated in **Appendix D**) is routed through the existing condition of the riparian buffer. The resulting load then represents the upland BMP load corrected for the existing riparian health condition. It should be noted that the reductions gained through this modeling effort are the same as the reductions modeled in the USLE modeling effort (**Appendix D**). However, the final delivered loads are reduced via riparian filtering.

Scenario 3: Upland & Riparian BMP Scenario
This scenario provides an assessment of the additional sediment load reductions that could be gained through the application of BMPs applied to land use / land management activities within the riparian buffer. For this scenario the upland erosion USLE generated BMP load (calculated in Appendix D) is routed through the potential BMP condition of the riparian buffer. The resulting load then represents the upland BMP load corrected for the riparian health BMP condition.

Under this BMP scenario, it is assumed that the implementation of BMPs on those activities that affect the overall health of the vegetated riparian buffer increases the watershed scale riparian health condition from its existing condition to 75 percent of the total stream length with a Good riparian health condition and 25 percent of the total stream length with a Fair condition. The concept is that through the application of BMPs, the general health of the vegetated riparian buffer will increase, hence increasing its sediment reduction efficiency. Twenty five percent of the stream will be left in Fair condition because it is assumed that there will always be some reasonable level of disturbance within the vegetated riparian buffer.

Results

A simple spreadsheet modeling approach was formulated to facilitate data manipulation and to generate output for this report. The results and reductions associated with the three scenarios described above are presented by 303(d) Listed tributary in **Table E-2**.

A schematic diagram of all three scenarios described above is presented in **Figure E-4** for Big Pipestone Creek. The existing upland sediment load delivered to the stream network from grazing sources within the Big Pipestone Creek watershed is 1547 tons/year (**Scenario 1**). Through the application of upland BMPs , in this case grazing practices, it is estimated that the existing sediment load could be reduced by 25 percent to 1154 tons/year (**Scenario 2**). Furthermore, through the application of BMPs applied to land use / land management activities within the riparian buffer, it is estimated that the sediment load could be further reduced by an additional 45 percent to 633 tons/year (**Scenario 3**). In total, through implementation of upland and riparian BMPs the existing upland sediment load from grazing sources within the Big Pipestone Creek watershed was reduced by 59 percent, from 1547 to 633 tons/year.

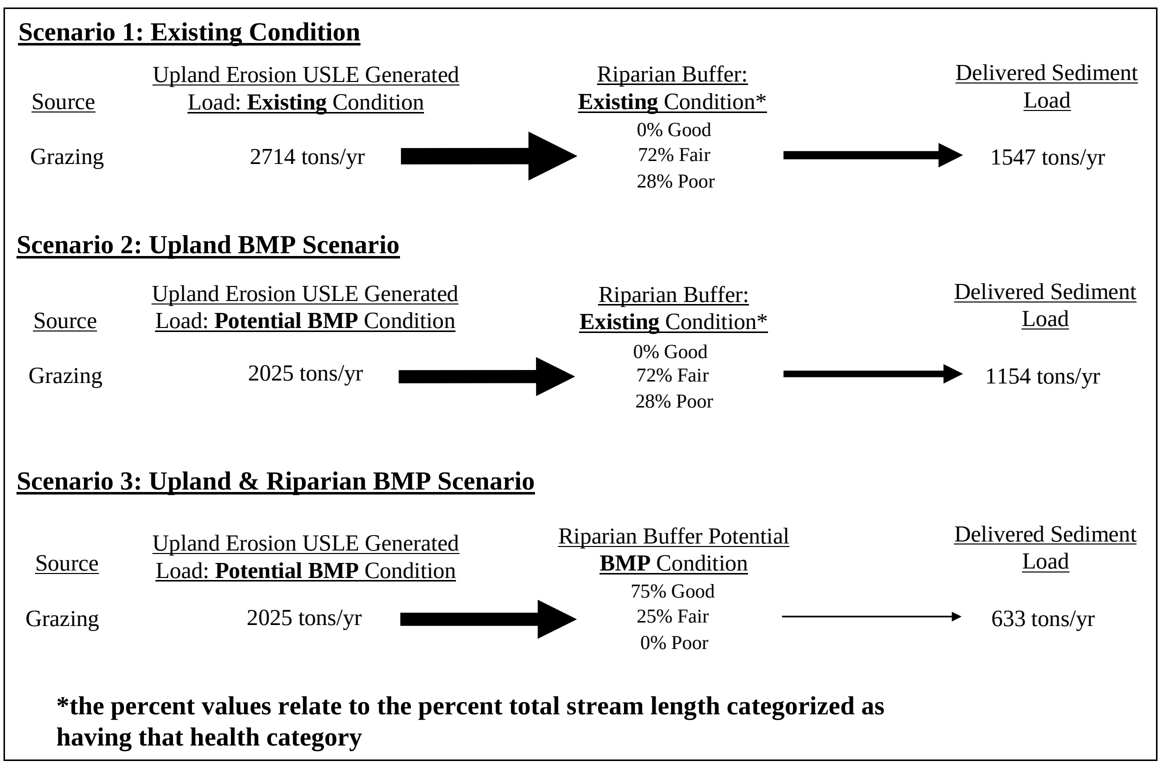


Figure E-4. Big Pipestone Creek Example of the three scenarios.

Table E-2- Upland sediment loading summary and percent reductions by watershed.

Watershed	Sources	Delivered Sediment Load (tons/year)					Overall Sediment Load Reduction
		Scenario 1	Scenario 2		Scenario 3		
		Upland Erosion USLE Load Corrected for Existing Riparian Health	Upland Erosion USLE BMP Load Corrected for Existing Riparian Health Condition (tons/yr)	Upland BMP Load Reduction	Upland Erosion USLE BMP Load Corrected for Riparian BMP Health Condition (tons/yr)	Riparian BMP Load Reduction	
Big Pipestone Creek	Grazing	1547	1154	25%	633	45%	59%
	Crops	46	7	84%	4	45%	91%
	Silviculture	2	2	0%	1	45%	45%
	Natural Sources	282	282	0%	155	45%	45%
	Total	**1877**	**1446**	**23%**	**793**	**45%**	**58%**
Cherry Creek	Grazing	234	179	23%	106	41%	55%
	Crops	0.34	0.22	35%	0.13	41%	62%
	Natural Sources	18	18	0%	11	41%	41%
	Total	**252**	**198**	**22%**	**117**	**41%**	**54%**
Fish Creek	Grazing	690	514	25%	306	40%	56%
	Crops	3	1	55%	1	40%	73%
	Silviculture	2	2	0%	1	40%	40%
	Natural Sources	122	122	0%	72	40%	41%
	Total	**817**	**640**	**22%**	**381**	**40%**	**53%**
Fitz Creek	Grazing	118	92	22%	58	38%	51%
	Crops	3.97	0.50	87%	0.31	38%	92%
	Natural Sources	8	8	0%	5	38%	38%
	Total	**130**	**101**	**22%**	**63**	**38%**	**51%**
Halfway Creek	Grazing	67	47	30%	40	14%	39%
	Natural Sources	19	19	0%	16	14%	14%
	Total	**85**	**66**	**23%**	**57**	**14%**	**34%**
Hells Canyon Creek	Grazing	668	520	22%	371	29%	44%
	Natural Sources	57	57	0%	41	29%	29%
	Total	**725**	**577**	**20%**	**412**	**29%**	**43%**
Little Pipestone Creek	Grazing	534	405	24%	197	51%	63%
	Crops	2	1	66%	0	51%	83%
	Silviculture	0.39	0.39	0%	0.19	51%	51%
	Natural Sources	73	73	0%	35	51%	51%
	Total	**609**	**479**	**21%**	**233**	**51%**	**62%**
Whitetail Creek	Grazing	2490	1920	23%	1122	42%	55%
	Crops	90	11	88%	6	42%	93%
	Silviculture	2	2	0%	1	42%	42%
	Natural Sources	270	270	0%	158	42%	42%
	Total	**2852**	**2203**	**23%**	**1287**	**42%**	**55%**

APPENDIX F
UNPAVED ROAD SEDIMENT ASSESSMENT, UPPER JEFFERSON RIVER TMDL PLANNING AREA

1.0 INTRODUCTION

This report presents a sediment assessment of the unpaved road network within the Upper Jefferson River TMDL Planning Area (TPA). This assessment was performed as part of the development of sediment TMDLs for 303(d) Listed stream segments with sediment as a documented impairment. Through a combination of GIS analysis, field assessment, and modeling, estimated sediment loads were developed for both road crossings and parallel road segments. Existing road conditions were modeled, as well as estimated future road conditions after the application of sediment reducing Best Management Practices (BMPs).

The 1996 303(d) List included a total of 10 impaired streams within the Upper Jefferson River TPA: Big Pipestone Creek, Cherry Creek, Dry Boulder Creek, Fish Creek, Fritz Creek, Halfway Creek, Hells Canyon Creek, Little Pipestone Creek, Whitetail Creek, and the Jefferson River (**Figure 1**). All streams were listed for siltation on the 1996 303(d) List with the exception of Cherry Creek, which was listed for flow alterations. The 2006 303(d) List includes Big Pipestone Creek, Hells Canyon Creek, Little Pipestone Creek, Whitetail Creek, Jefferson River, Cherry Creek, Fish Creek and Fitz Creek for sediment related impairments.

2.0 DATA COLLECTION

The Upper Jefferson Road Sediment assessment consisted of three primary tasks: 1.) GIS Layer development, 2.) field assessment and sediment modeling, and 3.) sediment load calculations and allocations for listed watersheds and the entire Upper Jefferson River TPA. Additional information on assessment techniques is available in prior reporting for this project: *Task 1. Road GIS Layers and Summary Statistics* (MDEQ 2006), and *Task 2. Sampling and Analysis Plan* (MDEQ 2006).

2.1 Spatial Analysis

Unpaved crossings and parallel segments in the road network were identified and classified relative to landscape type, land ownership, and 6th code subwatershed. These classifications captured a statistically representative sample of roads within the entire watershed, based on a number of road conditions (subwatershed, road design, soil type, maintenance level, etc). A total of 1441 unpaved road crossings were identified based on the GIS analysis; forty seven percent (675 crossings) in the mountain landscape, forty four percent (641 crossings) in the foothill landscape, and nine percent (125 crossings) in the valley landscape. A random subset of unpaved crossing sites were generated for field assessment based on the proportion of total crossings within each landscape type, with approximately 4 percent of the total unpaved crossings assessed. Parallel road segments were identified as areas where roads encroach upon the stream channel, and total road lengths within 150-foot and 300-foot buffer zones were generated. There was a total of 439 miles of unpaved parallel road segments within 300 feet of stream channels and 262 miles within 150 feet.

2.2 Field Data Collection

A total of 60 unpaved crossings and 23 unpaved parallel segments were evaluated in the field (**Figure 2**). Twenty six crossings were assessed in the mountain landscape, 29 crossings were assessed in the foothill landscape, and 5 crossings were assessed in the valley landscape type. In the field, near stream segments were selected based on best professional judgment while traveling roads on which specific crossings were selected for evaluation. Parallel segments were selected in a manner where road segments would not be duplicated in both the crossing and parallel sediment load calculations. Seventeen parallel segments were assessed in the mountain landscape type and 6 segments were assessed in the foothill landscape type. No parallel segments were assessed in the valley landscape type due to the small overall area of the valley landscape, and the observation that the majority of the roads were paved and/or did not parallel a stream channel. Field data spreadsheets with detailed information on each road crossing and parallel segment are included in **Attachment A** and **Attachment B**.

2.3 Sediment Assessment Methodology

The road sediment assessment was conducted using the WEPP:Road forest road erosion prediction model (http://forest.moscowfsl.wsu.edu/fswepp/). WEPP:Road is an interface to the Water Erosion Prediction Project (WEPP) model (Flanagan and Livingston, 1995), developed by the USDA Forest Service and other agencies, and is used to predict runoff, erosion, and sediment

delivery from forest roads. The model predicts sediment yields based on specific soil, climate, ground cover, and topographic conditions. Specifically, the following model input data was collected in the field: soil type, percent rock, road surface, road design, traffic level, and specific road topographic values (road grade, road length, road width, fill grade, fill length, buffer grade, and buffer length). Site specific climate profiles were developed for each landscape type using data from the Western Regional Climate Center (http://www.wrcc.dri.edu). Fifty year simulations were run for each unpaved road crossing and parallel road segment.

2.4 Error Reduction

Field conditions required that a number of sites be moved to different locations due to lack of access (landowner permission or road condition), lack of an existing stream channel, or inaccuracies in the road or stream GIS layers, which showed crossings that weren't present. It was also noted during field activities that some roads showed up as paved on the GIS layers, when, in fact, they were improved gravel roads. Records were kept in the field and edits were made to the GIS layers. Revised road network statistics were generated, which resulted in unpaved road crossings increasing from 1441 to 1549 crossings.

A visual assessment of the road system was also conducted using 2005 color aerial infrared photography to identify and remove incorrect road crossings. Most errors were noted along boundary edges where different road layers overlapped each other, or along confined valley bottoms where a road and stream paralleled each other. Incorrect road crossings were marked as such in the GIS data file, and removed from the final sediment loading calculations. The presence of heavy foliage in narrow valleys made identification of incorrect crossings difficult in some areas. Crossings were only removed if they could be positively identified as incorrect. The entire road system within all 303(d) Listed watersheds were evaluated using aerial photography, and average error percentages were calculated for each landscape type. Mountain landscape types had an average error of 8.5 percent, foothill landscape types had an average error of 6.3 percent, and valley landscape types had an average error of 5 percent. These average error percentages were then applied to the remainder of the Upper Jefferson River watershed to determine a final unpaved road crossing tally of 1419 crossings, 660 mountain crossings, 626 foothill crossings, and 133 valley crossings (**Table 2-1**). The ability to generate completely accurate road and stream crossing layers is not feasible; however, this revised tally represents a more accurate representation of existing conditions.

Table 2-1. Total Revised Number of Unpaved Crossings

Landscape Type	Unpaved Road Crossings using GIS Only	Revised Unpaved Crossings After Field Adjustments	Final Number of Unpaved Crossings After Aerial Photo Adjustments
Mountain	675	721	660
Foothill	641	688	626
Valley	125	140	133
Total	**1441**	**1549**	**1419**

Parallel road segments within 150-foot and 300-foot buffer distances from all identified stream channels were identified using GIS; however, field conditions demonstrated that roads more than 150-feet from a stream channel did not appear to be a sediment source. A total of 439 miles of

parallel road is present within 300-feet of stream channels and 262 miles of parallel road is within 150-feet. This distance was further reduced to 100-feet based on modeling results showing low sediment load from three assessed segments outside this distance. A total of 189 miles of parallel road are present in the watershed within a 100 foot buffer distance, and all parallel road sediment load calculations were based on this value (**Table 2-2**).

Table 2-2. Total Revised Parallel Road Distance

Landscape Type	Parallel Distance Within 300-ft of Streams (miles)	Parallel Distance Within 150-ft of Streams (miles)	Parallel Distance Within 100-ft of Streams (miles)
Mountain	203.2	130.5	95.8
Foothill	198.3	111.9	79.3
Valley	37.8	20.0	13.9
Total	**439.3**	**262.4**	**189.0**

2.5 Mean Sediment Loads

Field assessment data and modeling results were used to calculate mean sediment loads from the unpaved road network by landscape type. Mean sediment loads from unpaved road crossings were estimated at 0.07 tons/year for mountain crossings, 0.62 tons/year for foothill crossings, and 0.11 tons/year for valley crossings. Mean sediment loads were calculated for parallel road segments, and loads were then normalized to 1000-feet to account for differences in contributing road length. Mean sediment loads from unpaved parallel road segments were estimated at 0.32 tons/year/1000-feet in mountain landscapes and 0.39 tons/year/1000-feet in foothill landscapes. No valley parallel segments were assessed in the field due to the small overall area of the valley landscape and the majority presence of paved roads or roads that did not parallel streams. As a result, the mean sediment loads from the mountain and foothill parallel segments were averaged together to obtain an estimated sediment load of 0.36 tons/year/1000-feet for valley parallel segments (**Table 2-3**).

Table 2-3. Mean Sediment Load from Field Assessed Sites

Road Feature	Landscape Type	Number of Sites Assessed	Mean Contributing Length (ft)	Mean Sediment Load (tons/yr)
Crossing	Mountain	26	330	0.07
Crossing	Foothill	29	409	0.62
Crossing	Valley	5	665	0.11
Total:		**60**		
Road Feature	**Landscape Type**	**Number of Sites Assessed**	**Mean Contributing Length (ft)**	**Mean Sediment Load Per 1000 feet (tons/yr)**
Parallel	Mountain	15	587	0.32
Parallel	Foothill	5	457	0.39
Parallel	Valley	0	no data	no data
Total:		**20***		

***** = Three sites with buffer distances greater than 100-feet were removed from the load calculations.

2.6 Extrapolation to Watershed Scale

Total road crossings and parallel road distances were further defined by land ownership and subwatershed. USGS 6th code subwatersheds (HUC_12) were used as a basis for road sediment categorization in order to provide means for identifying the most impacted areas, and opportunities, for potential restoration planning. Some listed watersheds did not correlate with the HUC_12 boundaries; in these instances, the listed watersheds were digitized separately and included as a standalone unit in the load summary analyses. If a listed watershed existed within the boundary of another HUC_12, results were reported separately to avoid duplication. All streams with sediment as a listed impairment on either the 1996 or 2004 303(d) List were reported separately (**Table 2-4** and **Table 2-5**).

The road network was also classified by major landowner within the watershed, as various entities are responsible for operation and maintenance of the system. Four major landowner classifications were developed: United States Forest Service (USFS), United States Bureau of Land Management (BLM) & U.S. Fish & Wildlife Service (USFWS), State of Montana (School Trust and Fish Wildlife, and Parks(FWP)), and private landowners. Due to the insignificant road network impact from USFWS and Montana FWP lands, they were combined with other applicable land classifications. USFWS land was combined with BLM land into a BLM_USFWS category, and FWP land was combined with Montana State Trust land into a State category. Road features and sediment load results are reported by these major land categories.

3.0 ROAD SEDIMENT ANALYSIS

Mean sediment loads from field assessed sites were used to extrapolate loads throughout the entire watershed. Mean loads for unpaved crossings were applied to the total number of crossings within each landscape type, and normalized mean parallel segment loads were applied to the entire parallel distance within 100-feet of streams. For valley parallel road segments, mean results for the mountain and foothill landscape types were averaged to obtain a load value of 0.36 tons/year/1000-feet. Sediment loads were extrapolated to the entire watershed and were sorted by landscape type.

The total Upper Jefferson River Watershed sediment load from unpaved road crossings was estimated to be 449 tons/year, and the total sediment load from unpaved parallel segments within 100-feet of streams was estimated to be 351 tons/year (**Table 3-1**).

Table 3-1. Sediment Load Summary from Unpaved Road Network – Existing Conditions

Road Feature	Landscape Type	Total Number of Sites	Mean Sediment Load (Tons/year)	Total Sediment Load (Tons/year)
Crossing	Mountain	660	0.07	46.2
Crossing	Foothill	626	0.62	388.1
Crossing	Valley	133	0.11	14.6
Total:				**448.9**
Road Feature	**Landscape Type**	**Total Parallel Distance Within 100-feet (Miles)**	**Mean Sediment Load (Tons/year/1000 ft)**	**Total Sediment Load (Tons/year)**
Parallel	Mountain	95.81	0.32	161.9
Parallel	Foothill	79.29	0.39	163.3
Parallel	Valley	13.86	0.36	26.0
Total:		**188.96**		**351.2**
Total Upper Jefferson TPA:				**800.1**

3.1 Sediment Load from Road Crossings

Road crossing results showed that Whitetail Creek (62.6 tons/year), Big Pipestone Creek (61.4 tons/year), and Little Whitetail Creek (49.4 tons/year) contained the three highest sediment loads from unpaved road crossings (**Table 3-2**). The total sediment load from unpaved crossings was 449 tons/year from a total of 1419 crossings, or an average of 0.32 tons/year/crossing across all landscape types. The majority of sediment load is generated from crossings on private land (311.1 tons/year), followed by BLM/USFWS land (64.2 tons/year), and USFS land (48.4 tons/year).

3.2 Sediment Load from Parallel Road Segments

Parallel road segment results showed that the Big Pipestone Creek (40.6 tons/year), Little Whitetail Creek (37 tons/year), and Jefferson River-Mill Creek (33.8 tons/year) watersheds contained the three highest sediment loads from parallel road segments (**Table 3-3**). The total

sediment load from parallel road segments was 351 tons/year from a total of 189 miles of road within 100-feet of streams, or an average of 1.86 tons/year/mile across all landscape types. The majority of sediment load is generated from parallel road segments on private land (176.3 tons/year), followed by USFS land (123.6 tons/year), and BLM/USFWS land (42.5 tons/year).

3.3 Total Sediment Loading

Results from unpaved road crossings and parallel road segments were combined to determine the total sediment load breakdown for the watershed. Combined total sediment loads showed that Big Pipestone Creek (102 tons/year), Whitetail Creek (94.3 tons/year), and Little Whitetail Creek (86.4 tons/year) contained the three highest sediment loads from the unpaved road network (**Table 3-4**).

4.0 APPLICATION OF BEST MANAGEMENT PRACTICES

Sediment impacts are widespread throughout the Upper Jefferson River TMDL Planning Area, and sediment loading from the unpaved road network is one of several sources within the watershed. Application of Best Management Practices (BMPs) on the unpaved road network will result in a decrease in sediment loading to streams. Estimated load reductions were calculated by assuming a uniform reduction in contributing road length for each unpaved crossing and parallel road segment assessed in the field. For crossing locations, the reduced contributing length assumes that the crossing is located in the center of the total length. For parallel segments, the reduced contributing length corresponds with the parallel road segment. Due to the extent of the unpaved road network and the resulting inability to assess it in its entirety, generalized assumptions are necessary for modeling the affects of BMPs. Restoration efforts would need to consider site specific BMPs that, on average, would likely be represented by the modeling assumptions.

4.1 Contributing Road Length Reduction Scenarios

Two contributing road length reduction scenarios were evaluated: the first assumes a length reduction to 200 feet (100-feet on each side of a crossing) and the second assumes a length reduction to 500 feet (250-feet on each side of a crossing). On crossing locations in excess of each length reduction scenario, road lengths were reduced to the corresponding post-BMP scenario (200-feet or 500-feet). No changes were made to crossing locations where the contributing road length was less than the BMP reduction scenario. For parallel road segments in excess of each length reduction scenario, road and fillslope lengths were reduced to the corresponding post-BMP scenario (200-feet or 500-feet). No changes were made to parallel locations where the contributing road length was less than the BMP reduction scenario. Each BMP scenario (200-feet and 500-feet) was evaluated using the WEPP: Road forest road erosion prediction model, so potential sediment load reductions could be estimated. Reduced mean sediment loads were extrapolated to the watershed scale using the total refined number of unpaved road crossings, and the total parallel road length within 100-feet of streams.

For the 200-foot BMP scenario, mean sediment loads would be reduced from 0.07 tons/year to 0.03 tons/year for mountain crossings, from 0.62 tons/year to 0.07 tons/year for foothill crossings, and from 0.11 tons/year to 0.05 tons/year for valley crossings (**Table 4-1**). Sediment load from road crossings would be reduced from 448.9 tons/year to 68.5 tons/year (84.8 percent), and sediment load from parallel road segments would be reduced from 351.1 tons/year to 257.6 tons/year (26.6 percent). The significant reduction in road crossing load results occurs primarily within the foothill landscape type, where a small number of field sites had extended road lengths and contributed a majority of the sediment load. Reduction in the contributing road length had a major impact on these sites, resulting in a decreased average sediment load.

Table 4-1. Estimated Sediment Load Summary – Reduce Road Length to 200-feet

Road Feature	Landscape Type	Total Number of Sites	Mean Sediment Load (Tons/year)	Total Sediment Load (Tons/year)	Load Reduction %
Crossing	Mountain	660	0.03	21.8	52.9%
Crossing	Foothill	626	0.07	40.7	89.5%
Crossing	Valley	133	0.05	6.0	59.1%
Total				**68.5**	**84.8%**
Road Feature	**Landscape Type**	**Total Parallel Distance Within 100-feet (Miles)**	**Mean Sediment Load (Tons/year/1000 ft)**	**Total Sediment Load (Tons/year)**	**Load Reduction %**
Parallel	Mountain	95.81	0.24	121.4	25.0%
Parallel	Foothill	79.29	0.28	117.2	28.2%
Parallel	Valley	13.86	0.26	19.0	26.8%
Total		**188.96**		**257.6**	**26.6%**
Total Upper Jefferson TPA:				**326.1**	**59.2%**

For the 500-foot BMP scenario, mean sediment loads would be reduced from 0.07 tons/year to 0.06 tons/year for mountain crossings, from 0.62 tons/year to 0.27 tons/year for foothill crossings, and from 0.11 tons/year to 0.08 tons/year for valley crossings (**Table 4-2**). Sediment load from road crossings would be reduced from 448.9 tons/year to 220.6 tons/year (50.9 percent), and sediment load from parallel road segments would be reduced from 351.1 tons/year to 316.6 tons/year (9.8 percent).

Table 4-2. Estimated Sediment Load Summary – Reduce Road Length to 500-feet

Road Feature	Landscape Type	Total Number of Sites	Mean Sediment Load (Tons/year)	Total Sediment Load (Tons/year)	Load Reduction %
Crossing	Mountain	660	0.06	41.6	10.0%
Crossing	Foothill	626	0.27	169.0	56.5%
Crossing	Valley	133	0.08	10.0	31.8%
Total				**220.6**	**50.9%**
Road Feature	**Landscape Type**	**Total Parallel Distance Within 100-feet (Miles)**	**Mean Sediment Load (Tons/year/1000 ft)**	**Total Sediment Load (Tons/year)**	**Load Reduction %**
Parallel	Mountain	95.81	0.29	146.7	9.4%
Parallel	Foothill	79.29	0.35	146.5	10.3%
Parallel	Valley	13.86	0.32	23.4	9.9%
Total		**188.96**		**316.6**	**9.8%**
Total Upper Jefferson TPA:				**537.2**	**32.9%**

4.2 Total Estimated Sediment Load Reductions

Total estimated sediment load would be reduced from 800.1 tons/year to 326.1 tons/year (59.2 percent) for the 200-foot BMP scenario, and total sediment load would be reduced from 800.1

tons/year to 537.2 tons/year (32.9 percent) for the 500-foot BMP scenario. Unpaved road crossings, parallel road segments, and total estimated sediment load reductions for the 200-foot and 500-foot BMP scenarios were further classified by each listed watershed or 6th code HUC, landscape type, and land ownership. (**Table 4-3** through **Table 4-8**). Total estimated sediment loads and percent reductions for the 200-foot and 500-feet BMP scenarios by subwatershed are shown in **Table 4-9**.

Table 4-9. Total Estimated Sediment Load Reductions after Application of BMPs

Watershed	Total Sediment Load Existing Conditions (tons/year)	Total Sediment Load After 200 ft Road Length BMP (tons/year)	Percent Reduction in Sediment Load after 200-foot BMP Reduction	Total Sediment Load After 500 ft Road Length BMP (tons/year)	Percent Reduction in Sediment Load after 500-foot BMP Reduction
Big Pipestone Creek	102.0	39.2	61.6%	67.0	34.3%
Cherry Creek	19.0	5.6	70.4%	11.1	41.8%
Dry Boulder Creek	5.3	2.9	44.9%	4.2	21.1%
Little Pipestone Creek	36.5	21.9	39.8%	30.2	17.2%
Whitetail Creek	94.3	31.7	66.4%	58.3	38.2%
Fish Creek	51.9	25.0	51.9%	37.9	27.1%
Fritz Creek	9.2	3.9	57.2%	6.3	31.9%
Halfway Creek	8.0	5.6	30.7%	7.3	9.5%
Hells Canyon Creek	20.8	12.9	38.2%	17.3	16.6%
Homestake Creek	23.5	16.1	31.4%	21.3	9.5%
Dry Creek	38.1	9.8	74.2%	21.0	44.8%
Little Whitetail Creek	86.4	36.0	58.3%	59.2	31.5%
Jefferson River-Cardwell	71.5	25.1	64.9%	44.4	37.9%
Jefferson River-Cottonwood Creek	29.8	9.0	70.0%	17.4	41.7%
Jefferson River-Dry Boulder Creek	30.4	12.1	60.2%	20.1	33.8%
Jefferson River-Mill Creek	57.8	28.8	50.3%	42.7	26.2%
Jefferson River-Silver Star	25.4	10.0	60.8%	16.6	34.6%
Jefferson Slough	57.7	19.7	65.9%	35.4	38.6%
Piedmont Swamp	32.5	10.9	66.5%	19.8	39.1%
Total Upper Jefferson TPA:	**800.1**	**326.1**	**59.2%**	**537.2**	**32.9%**

4.3 Additional BMPs

As an alternative to or in combination with reductions in contributing road length, other potential BMPs are available that would reduce sediment loading from the unpaved road network. Road sediment reduction strategies such as road surface improvement, reduction in road traffic levels (seasonal or permanent road closures), timely road maintenance to reduce surface rutting, and

installation of culverts at ford crossings are all BMPs that would lead to reduced sediment loading from the road network. These alternative BMPs have not been evaluated as part of this report, but could be addressed at a later time, if necessary.

5.0 REFERENCES

MDEQ 2006. Task 1. Road GIS & Summary Statistics, Upper Jefferson River Watershed. Prepared by Water & Environmental Technologies, PC. Prepared for Montana Department of Environmental Quality, Water Quality Planning Bureau, Helena, Montana.

MDEQ 2006. Task 2. Sampling and Analysis Plan, Upper Jefferson River Watershed. Prepared by Water & Environmental Technologies, PC. Prepared for Montana Department of Environmental Quality, Water Quality Planning Bureau, Helena, Montana.

MDEQ 2007. Unpaved Road Runoff Sediment Assessment. Prepared by PBS&J, Helena, Montana. Prepared for Montana Department of Environmental Quality, Water Quality Planning Bureau, Helena, Montana.

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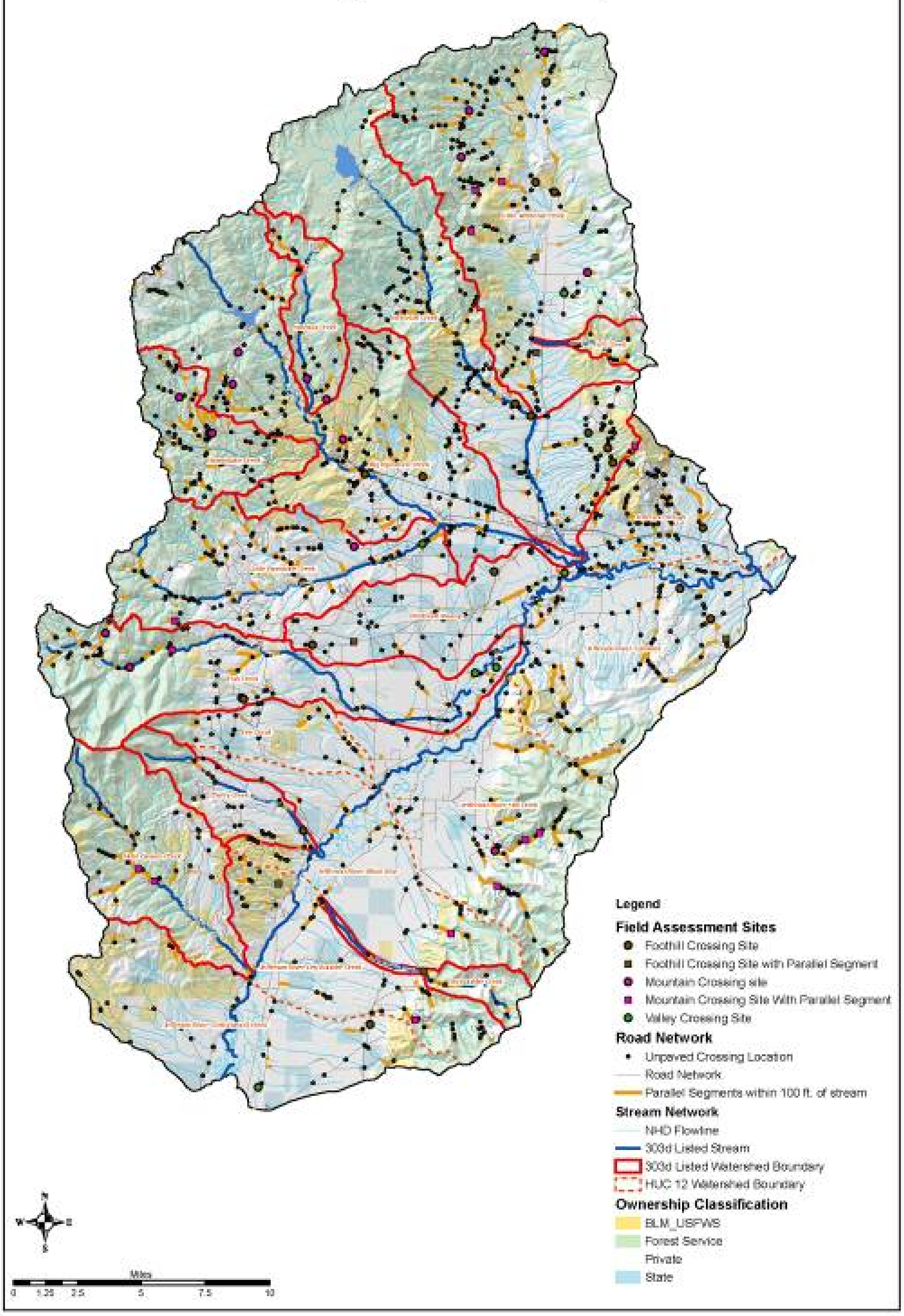

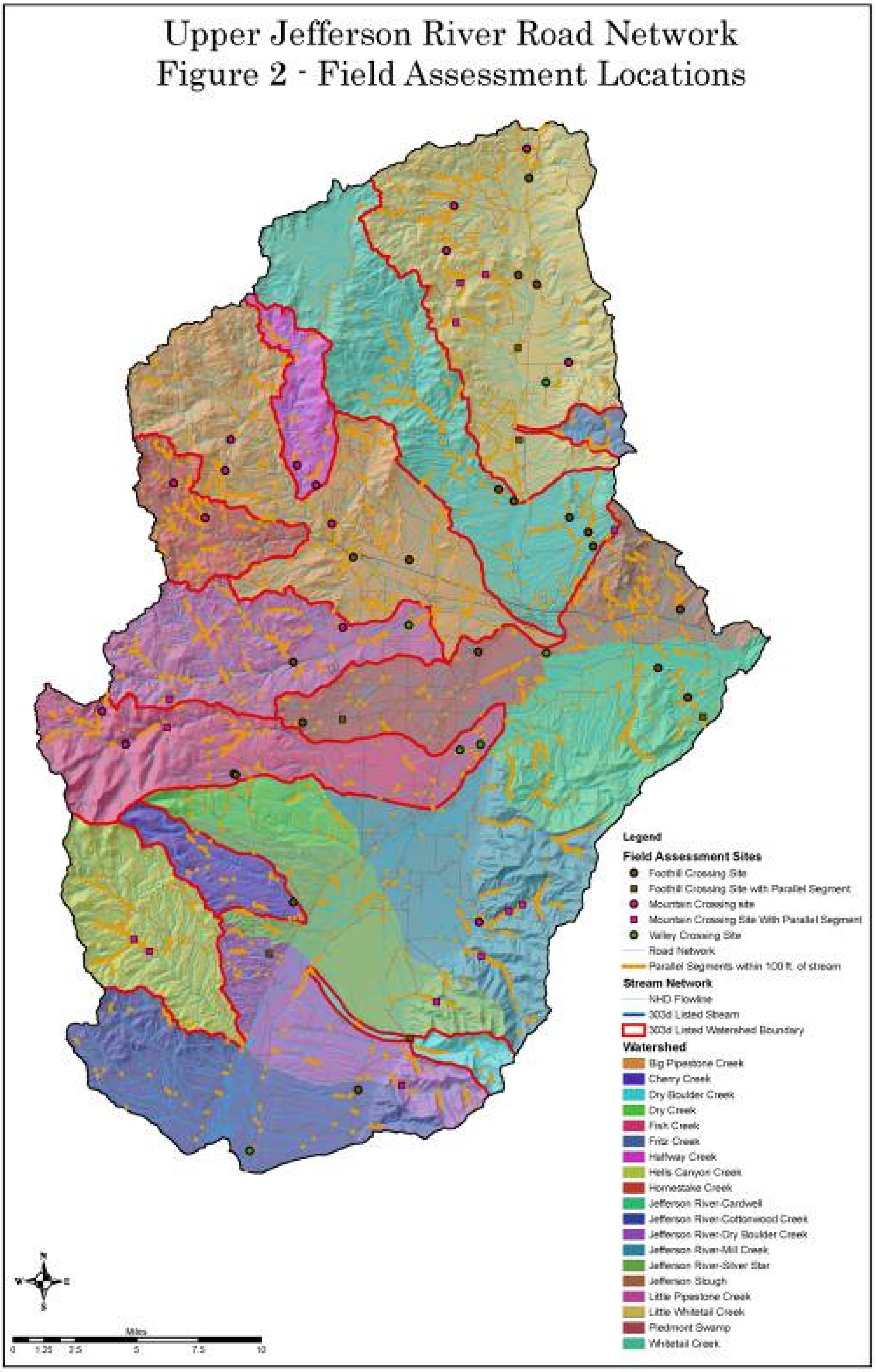
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Table 2-4. Detailed Revised Number of Unpaved Road Crossings

Ownership	**1996/ 2004 303(d)**	**Private**			**State**			**BLM_USFWS**			**Forest Service**			**Total Crossings**
Watershed		**Valley**	**Foothill**	**Mountain**	**Valley**	**Foothill**	**Mountain**	**Valley**	**Foothill**	**Mountain**	**Valley**	**Foothill**	**Mountain**	
Big Pipestone Creek	Yes	6	65	17	0	7	0	0	14	28	0	0	61	198
Cherry Creek	Yes	0	18	5	0	0	0	0	3	0	0	0	0	26
Dry Boulder Creek	Yes	1	1	2	0	1	0	0	0	2	0	0	6	13
Little Pipestone Creek	Yes	7	9	42	0	0	0	0	0	4	0	0	27	89
Whitetail Creek	Yes	5	53	14	1	10	0	0	24	6	0	5	50	168
Fish Creek	Yes	13	30	27	0	0	0	0	0	0	0	0	33	103
Fritz Creek	Yes	0	4	0	0	0	0	0	1	0	0	2	4	11
Halfway Creek	Yes	0	0	0	0	0	0	0	0	1	0	0	22	23
Hells Canyon Creek	Yes	0	4	7	0	0	0	0	0	0	0	1	26	38
Homestake Creek	No	0	0	14	0	0	0	0	0	1	0	0	62	77
Dry Creek	No	1	39	2	0	6	0	0	1	1	0	0	0	50
Little Whitetail Creek	No	11	43	12	0	0	0	0	16	16	0	5	93	196
Jefferson River-Cardwell	No	11	56	0	1	5	0	0	3	0	0	4	0	80
Jefferson River-Cottonwood Creek	No	8	17	0	1	5	0	0	10	1	0	0	0	42
Jefferson River-Dry Boulder Creek	No	1	15	2	0	1	0	0	9	6	0	0	12	46
Jefferson River-Mill Creek	No	8	18	10	1	0	0	0	2	0	0	12	36	87
Jefferson River-Silver Star	No	9	17	4	0	1	0	0	3	1	0	0	3	38
Jefferson Slough	No	26	44	0	0	1	0	0	10	0	0	0	0	81
Piedmont Swamp	No	22	28	0	0	3	0	0	0	0	0	0	0	53
Total Upper Jefferson:		***129***	***461***	***158***	***4***	***40***	***0***	***0***	***96***	***67***	***0***	***29***	***435***	***1419***

Table 2-5. Detailed Revised Parallel Road Distance

Ownership	1996 / 2004 303(d)	Private			State			BLM_USFWS			Forest Service			Total Miles
Watershed		**Valley**	**Foothill**	**Mountain**	**Valley**	**Foothill**	**Mountain**	**Valley**	**Foothill**	**Mountain**	**Valley**	**Foothill**	**Mountain**	
Big Pipestone Creek	Yes	0.66	6.37	1.88	0.00	0.72	0.08	0.00	1.64	2.44	0.00	0.00	8.24	22.03
Cherry Creek	Yes	0.00	1.76	0.84	0.00	0.00	0.00	0.00	0.29	0.00	0.00	0.00	0.00	2.89
Dry Boulder Creek	Yes	0.05	0.20	0.26	0.00	0.09	0.00	0.00	0.00	0.42	0.00	0.00	0.84	1.86
Little Pipestone Creek	Yes	0.99	1.43	6.80	0.08	0.00	0.00	0.00	0.00	0.89	0.00	0.00	4.18	14.37
Whitetail Creek	Yes	0.28	4.31	0.91	0.20	0.99	0.00	0.00	2.69	0.32	0.00	1.26	5.75	16.70
Fish Creek	Yes	1.22	4.19	5.77	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.16	15.34
Fritz Creek	Yes	0.00	0.51	0.00	0.00	0.00	0.00	0.00	0.07	0.00	0.00	0.70	1.14	2.42
Halfway Creek	Yes	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.00	3.75	3.79
Hells Canyon Creek	Yes	0.00	1.12	0.87	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	6.46	8.78
Homestake Creek	No	0.00	0.00	1.81	0.00	0.00	0.00	0.00	0.00	0.08	0.00	0.00	8.83	10.72
Dry Creek	No	0.08	3.43	0.22	0.00	0.25	0.00	0.00	0.35	0.22	0.00	0.00	0.05	4.61
Little Whitetail Creek	No	0.63	3.95	1.63	0.00	0.00	0.00	0.00	1.03	1.97	0.00	0.48	10.97	20.66
Jefferson River-Cardwell	No	1.06	9.23	0.00	0.03	0.53	0.00	0.00	2.25	0.00	0.00	0.58	0.00	13.69
Jefferson River-Cottonwood Creek	No	0.43	1.61	0.00	0.04	0.43	0.17	0.00	1.47	0.31	0.00	0.00	0.00	4.46
Jefferson River-Dry Boulder Creek	No	0.45	2.08	0.40	0.00	0.12	0.00	0.00	1.46	0.75	0.00	0.00	1.79	7.05
Jefferson River-Mill Creek	No	0.81	3.00	2.44	0.04	0.00	0.00	0.00	0.78	0.00	0.00	4.73	6.25	18.04
Jefferson River-Silver Star	No	1.71	1.43	0.70	0.00	0.14	0.00	0.00	0.60	0.34	0.00	0.00	0.85	5.76
Jefferson Slough	No	1.90	6.40	0.00	0.00	0.27	0.00	0.00	1.66	0.00	0.00	0.00	0.00	10.23
Piedmont Swamp	No	3.21	2.19	0.00	0.00	0.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.56
Total Upper Jefferson:		***13.48***	***53.23***	***24.52***	***0.38***	***3.70***	***0.25***	***0.00***	***14.27***	***7.78***	***0.00***	***8.09***	***63.27***	***188.96***

Table 3-2. Sediment Load From Unpaved Road Crossings - Existing Conditions

Ownership		Private			State			BLM_USFWS			Forest Service			Total Load Tons/ Year
Watershed	1996 / 2004 303(d)	Load (tons/year)			Load (tons/year)			Load (tons/year)			Load (tons/year)			
		Valley	Foothill	Mountain	Valley	Foothill	Mountain	Valley	Foothill	Mountain	Valley	Foothill	Mountain	
Big Pipestone Creek	Yes	0.66	40.3	1.19	0	4.34	0	0	8.68	1.96	0	0	4.27	61.4
Cherry Creek	Yes	0	11.16	0.35	0	0	0	0	1.86	0	0	0	0	13.37
Dry Boulder Creek	Yes	0.11	0.62	0.14	0	0.62	0	0	0	0.14	0	0	0.42	2.05
Little Pipestone Creek	Yes	0.77	5.58	2.94	0	0	0	0	0	0.28	0	0	1.89	11.46
Whitetail Creek	Yes	0.55	32.86	0.98	0.11	6.2	0	0	14.88	0.42	0	3.1	3.5	62.6
Fish Creek	Yes	1.43	18.6	1.89	0	0	0	0	0	0	0	0	2.31	24.23
Fritz Creek	Yes	0	2.48	0	0	0	0	0	0.62	0	0	1.24	0.28	4.62
Halfway Creek	Yes	0	0	0	0	0	0	0	0	0.07	0	0	1.54	1.61
Hells Canyon Creek	Yes	0	2.48	0.49	0	0	0	0	0	0	0	0.62	1.82	5.41
Homestake Creek	No	0	0	0.98	0	0	0	0	0	0.07	0	0	4.34	5.39
Dry Creek	No	0.11	24.18	0.14	0	3.72	0	0	0.62	0.07	0	0	0	28.84
Little Whitetail Creek	No	1.21	26.66	0.84	0	0	0	0	9.92	1.12	0	3.1	6.51	49.36
Jefferson River-Cardwell	No	1.21	34.72	0	0.11	3.1	0	0	1.86	0	0	2.48	0	43.48
Jefferson River-Cottonwood Creek	No	0.88	10.54	0	0.11	3.1	0	0	6.2	0.07	0	0	0	20.9
Jefferson River-Dry Boulder Creek	No	0.11	9.3	0.14	0	0.62	0	0	5.58	0.42	0	0	0.84	17.01
Jefferson River-Mill Creek	No	0.88	11.16	0.7	0.11	0	0	0	1.24	0	0	7.44	2.52	24.05
Jefferson River-Silver Star	No	0.99	10.54	0.28	0	0.62	0	0	1.86	0.07	0	0	0.21	14.57
Jefferson Slough	No	2.86	27.28	0	0	0.62	0	0	6.2	0	0	0	0	36.96
Piedmont Swamp	No	2.42	17.36	0	0	1.86	0	0	0	0	0	0	0	21.64
Total Upper Jefferson:		***14.19***	***285.82***	***11.06***	***0.44***	***24.8***	***0***	***0***	***59.52***	***4.69***	***0***	***17.98***	***30.45***	***448.95***

Table 3-3. Sediment Load From Parallel Road Segments - Existing Conditions

Ownership		Private			State			BLM_USFWS			Forest Service			Total Load Tons/Year
Watershed	1996 / 303(d)	Load (tons/year)			Load (tons/year)			Load (tons/year)			Load (tons/year)			
		Valley	Foothill	Mountain	Valley	Foothill	Mountain	Valley	Foothill	Mountain	Valley	Foothill	Mountain	
Big Pipestone Creek	Yes	1.23	13.12	3.18	0.00	1.49	0.13	0.00	3.37	4.13	0.00	0.00	13.93	40.57
Cherry Creek	Yes	0.00	3.63	1.42	0.00	0.00	0.00	0.00	0.60	0.00	0.00	0.00	0.00	5.65
Dry Boulder Creek	Yes	0.10	0.42	0.43	0.00	0.18	0.00	0.00	0.00	0.71	0.00	0.00	1.42	3.27
Little Pipestone Creek	Yes	1.86	2.94	11.48	0.15	0.00	0.00	0.00	0.00	1.51	0.00	0.00	7.06	25.01
Whitetail Creek	Yes	0.52	8.88	1.53	0.37	2.04	0.00	0.00	5.53	0.53	0.00	2.60	9.71	31.72
Fish Creek	Yes	2.29	8.64	9.74	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.02	27.70
Fritz Creek	Yes	0.00	1.05	0.00	0.00	0.00	0.00	0.00	0.15	0.00	0.00	1.45	1.93	4.57
Halfway Creek	Yes	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.00	0.00	6.34	6.41
Hells Canyon Creek	Yes	0.00	2.30	1.47	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.68	10.92	15.37
Homestake Creek	No	0.00	0.00	3.06	0.00	0.00	0.00	0.00	0.00	0.14	0.00	0.00	14.91	18.11
Dry Creek	No	0.16	7.07	0.38	0.00	0.52	0.00	0.00	0.72	0.36	0.00	0.00	0.09	9.30
Little Whitetail Creek	No	1.17	8.13	2.76	0.00	0.00	0.00	0.00	2.12	3.32	0.00	0.99	18.54	37.03
Jefferson River-Cardwell	No	2.00	19.01	0.00	0.05	1.10	0.00	0.00	4.62	0.00	0.00	1.20	0.00	27.98
Jefferson River-Cottonwood Creek	No	0.81	3.32	0.00	0.07	0.88	0.29	0.00	3.03	0.52	0.00	0.00	0.00	8.92
Jefferson River-Dry Boulder Creek	No	0.84	4.29	0.67	0.00	0.25	0.00	0.00	3.00	1.27	0.00	0.00	3.02	13.34
Jefferson River-Mill Creek	No	1.51	6.17	4.12	0.07	0.00	0.00	0.00	1.60	0.00	0.00	9.74	10.57	33.79
Jefferson River-Silver Star	No	3.20	2.95	1.18	0.00	0.28	0.00	0.00	1.24	0.57	0.00	0.00	1.44	10.86
Jefferson Slough	No	3.57	13.18	0.00	0.00	0.55	0.00	0.00	3.41	0.00	0.00	0.00	0.00	20.71
Piedmont Swamp	No	6.01	4.51	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.86
Total Upper Jefferson:		***25.27***	***109.61***	***41.42***	***0.71***	***7.62***	***0.42***	***0.00***	***29.39***	***13.14***	***0.00***	***16.67***	***106.90***	***351.14***

Table 3-4. Total Sediment Load From Unpaved Road Network - Existing Conditions

Ownership		**Private**			**State**			**BLM_USFWS**			**Forest Service**			**Total Load Tons/ Year**
Watershed	**1996 / 2004 303(d)**	**Load (tons/year)**			**Load (tons/year)**			**Load (tons/year)**			**Load (tons/year)**			
		Valley	**Foothill**	**Mountain**	**Valley**	**Foothill**	**Mountain**	**Valley**	**Foothill**	**Mountain**	**Valley**	**Foothill**	**Mountain**	
Big Pipestone Creek	Yes	1.89	53.42	4.37	0.00	5.83	0.13	0.00	12.05	6.09	0.00	0.00	18.20	101.97
Cherry Creek	Yes	0.00	14.79	1.77	0.00	0.00	0.00	0.00	2.46	0.00	0.00	0.00	0.00	19.02
Dry Boulder Creek	Yes	0.21	1.04	0.57	0.00	0.80	0.00	0.00	0.00	0.85	0.00	0.00	1.84	5.32
Little Pipestone Creek	Yes	2.63	8.52	14.42	0.15	0.00	0.00	0.00	0.00	1.79	0.00	0.00	8.95	36.47
Whitetail Creek	Yes	1.07	41.74	2.51	0.48	8.24	0.00	0.00	20.41	0.95	0.00	5.70	13.21	94.32
Fish Creek	Yes	3.72	27.24	11.63	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.33	51.93
Fritz Creek	Yes	0.00	3.53	0.00	0.00	0.00	0.00	0.00	0.77	0.00	0.00	2.69	2.21	9.19
Halfway Creek	Yes	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.00	0.00	7.88	8.02
Hells Canyon Creek	Yes	0.00	4.78	1.96	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.30	12.74	20.78
Homestake Creek	No	0.00	0.00	4.04	0.00	0.00	0.00	0.00	0.00	0.21	0.00	0.00	19.25	23.50
Dry Creek	No	0.27	31.25	0.52	0.00	4.24	0.00	0.00	1.34	0.43	0.00	0.00	0.09	38.14
Little Whitetail Creek	No	2.38	34.79	3.60	0.00	0.00	0.00	0.00	12.04	4.44	0.00	4.09	25.05	86.39
Jefferson River-Cardwell	No	3.21	53.73	0.00	0.16	4.20	0.00	0.00	6.48	0.00	0.00	3.68	0.00	71.46
Jefferson River-Cottonwood Creek	No	1.69	13.86	0.00	0.18	3.98	0.29	0.00	9.23	0.59	0.00	0.00	0.00	29.82
Jefferson River-Dry Boulder Creek	No	0.95	13.59	0.81	0.00	0.87	0.00	0.00	8.58	1.69	0.00	0.00	3.86	30.35
Jefferson River-Mill Creek	No	2.39	17.33	4.82	0.18	0.00	0.00	0.00	2.84	0.00	0.00	17.18	13.09	57.84
Jefferson River-Silver Star	No	4.19	13.49	1.46	0.00	0.90	0.00	0.00	3.10	0.64	0.00	0.00	1.65	25.43
Jefferson Slough	No	6.43	40.46	0.00	0.00	1.17	0.00	0.00	9.61	0.00	0.00	0.00	0.00	57.67
Piedmont Swamp	No	8.43	21.87	0.00	0.00	2.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	32.50
Total Upper Jefferson:		***39.46***	***395.43***	***52.48***	***1.15***	***32.42***	***0.42***	***0.00***	***88.91***	***17.83***	***0.00***	***34.65***	***137.35***	***800.09***

Table 4-3. Estimated Sediment Load From Unpaved Road Crossings - Reduce Length to 200 Feet

Ownership		Private			State			BLM_USFWS			Forest Service			Total
Watershed	1996 / 2004 303(d)	Load (tons/year)			Load (tons/year)			Load (tons/year)			Load (tons/year)			Load Tons/ Year
		Valley	Foothill	Mountain	Valley	Foothill	Mountain	Valley	Foothill	Mountain	Valley	Foothill	Mountain	
Big Pipestone Creek	Yes	0.27	4.23	0.56	0.00	0.46	0.00	0.00	0.91	0.92	0.00	0.00	2.01	9.36
Cherry Creek	Yes	0.00	1.17	0.17	0.00	0.00	0.00	0.00	0.20	0.00	0.00	0.00	0.00	1.53
Dry Boulder Creek	Yes	0.05	0.07	0.07	0.00	0.07	0.00	0.00	0.00	0.07	0.00	0.00	0.20	0.51
Little Pipestone Creek	Yes	0.32	0.59	1.39	0.00	0.00	0.00	0.00	0.00	0.13	0.00	0.00	0.89	3.31
Whitetail Creek	Yes	0.23	3.45	0.46	0.05	0.65	0.00	0.00	1.56	0.20	0.00	0.33	1.65	8.56
Fish Creek	Yes	0.59	1.95	0.89	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.09	4.52
Fritz Creek	Yes	0.00	0.26	0.00	0.00	0.00	0.00	0.00	0.07	0.00	0.00	0.13	0.13	0.59
Halfway Creek	Yes	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.73	0.76
Hells Canyon Creek	Yes	0.00	0.26	0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.86	1.41
Homestake Creek	No	0.00	0.00	0.46	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00	2.05	2.54
Dry Creek	No	0.05	2.54	0.07	0.00	0.39	0.00	0.00	0.07	0.03	0.00	0.00	0.00	3.13
Little Whitetail Creek	No	0.50	2.80	0.40	0.00	0.00	0.00	0.00	1.04	0.53	0.00	0.33	3.07	8.65
Jefferson River-Cardwell	No	0.50	3.64	0.00	0.05	0.33	0.00	0.00	0.20	0.00	0.00	0.26	0.00	4.96
Jefferson River-Cottonwood Creek	No	0.36	1.11	0.00	0.05	0.33	0.00	0.00	0.65	0.03	0.00	0.00	0.00	2.52
Jefferson River-Dry Boulder Creek	No	0.05	0.98	0.07	0.00	0.07	0.00	0.00	0.59	0.20	0.00	0.00	0.40	2.33
Jefferson River-Mill Creek	No	0.36	1.17	0.33	0.05	0.00	0.00	0.00	0.13	0.00	0.00	0.78	1.19	4.00
Jefferson River-Silver Star	No	0.41	1.11	0.13	0.00	0.07	0.00	0.00	0.20	0.03	0.00	0.00	0.10	2.03
Jefferson Slough	No	1.17	2.86	0.00	0.00	0.07	0.00	0.00	0.65	0.00	0.00	0.00	0.00	4.75
Piedmont Swamp	No	0.99	1.82	0.00	0.00	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.01
Total Upper Jefferson:		***5.81***	***29.97***	***5.21***	***0.18***	***2.60***	***0.00***	***0.00***	***6.24***	***2.21***	***0.00***	***1.89***	***14.36***	***68.46***

Table 4-4. Estimated Sediment Load From Unpaved Crossings - Reduce Length to 500 Feet

Ownership		Private			State			BLM_USFWS			Forest Service			Total Load Tons/Year
Watershed	1996 / 2004 303(d)	Load (tons/year)			Load (tons/year)			Load (tons/year)						
		Valley	Foothill	Mountain	Valley	Foothill	Mountain	Valley	Foothill	Mountain	Valley	Foothill	Mountain	
Big Pipestone Creek	Yes	0.45	17.55	1.07	0.00	1.89	0.00	0.00	3.78	1.76	0.00	0.00	3.84	30.35
Cherry Creek	Yes	0.00	4.86	0.32	0.00	0.00	0.00	0.00	0.81	0.00	0.00	0.00	0.00	5.99
Dry Boulder Creek	Yes	0.08	0.27	0.13	0.00	0.27	0.00	0.00	0.00	0.13	0.00	0.00	0.38	1.25
Little Pipestone Creek	Yes	0.53	2.43	2.65	0.00	0.00	0.00	0.00	0.00	0.25	0.00	0.00	1.70	7.55
Whitetail Creek	Yes	0.38	14.31	0.88	0.08	2.70	0.00	0.00	6.48	0.38	0.00	1.35	3.15	29.70
Fish Creek	Yes	0.98	8.10	1.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.08	12.86
Fritz Creek	Yes	0.00	1.08	0.00	0.00	0.00	0.00	0.00	0.27	0.00	0.00	0.54	0.25	2.14
Halfway Creek	Yes	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.00	0.00	1.39	1.45
Hells Canyon Creek	Yes	0.00	1.08	0.44	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.27	1.64	3.43
Homestake Creek	No	0.00	0.00	0.88	0.00	0.00	0.00	0.00	0.00	0.06	0.00	0.00	3.91	4.85
Dry Creek	No	0.08	10.53	0.13	0.00	1.62	0.00	0.00	0.27	0.06	0.00	0.00	0.00	12.68
Little Whitetail Creek	No	0.83	11.61	0.76	0.00	0.00	0.00	0.00	4.32	1.01	0.00	1.35	5.86	25.73
Jefferson River-Cardwell	No	0.83	15.12	0.00	0.08	1.35	0.00	0.00	0.81	0.00	0.00	1.08	0.00	19.26
Jefferson River-Cottonwood Creek	No	0.60	4.59	0.00	0.08	1.35	0.00	0.00	2.70	0.06	0.00	0.00	0.00	9.38
Jefferson River-Dry Boulder Creek	No	0.08	4.05	0.13	0.00	0.27	0.00	0.00	2.43	0.38	0.00	0.00	0.76	8.09
Jefferson River-Mill Creek	No	0.60	4.86	0.63	0.08	0.00	0.00	0.00	0.54	0.00	0.00	3.24	2.27	12.21
Jefferson River-Silver Star	No	0.68	4.59	0.25	0.00	0.27	0.00	0.00	0.81	0.06	0.00	0.00	0.19	6.85
Jefferson Slough	No	1.95	11.88	0.00	0.00	0.27	0.00	0.00	2.70	0.00	0.00	0.00	0.00	16.80
Piedmont Swamp	No	1.65	7.56	0.00	0.00	0.81	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.02
Total Upper Jefferson:		***9.68***	***124.47***	***9.95***	***0.30***	***10.80***	***0.00***	***0.00***	***25.92***	***4.22***	***0.00***	***7.83***	***27.41***	***220.58***

Table 4-5. Estimated Sediment Load From Parallel Segments - Reduce to 200 foot Length

Ownership	1996 /	Private			State			BLM_USFWS			Forest Service			Total Load Tons/ Year
Watershed	2004 303(d)	Load (tons/year)			Load (tons/year)			Load (tons/year)			Load (tons/year)			
		Valley	Foothill	Mountain	Valley	Foothill	Mountain	Valley	Foothill	Mountain	Valley	Foothill	Mountain	
Big Pipestone Creek	Yes	0.90	9.42	2.38	0.00	1.07	0.10	0.00	2.42	3.10	0.00	0.00	10.45	29.83
Cherry Creek	Yes	0.00	2.61	1.06	0.00	0.00	0.00	0.00	0.43	0.00	0.00	0.00	0.00	4.10
Dry Boulder Creek	Yes	0.07	0.30	0.33	0.00	0.13	0.00	0.00	0.00	0.54	0.00	0.00	1.06	2.43
Little Pipestone Creek	Yes	1.37	2.11	8.61	0.11	0.00	0.00	0.00	0.00	1.13	0.00	0.00	5.30	18.63
Whitetail Creek	Yes	0.38	6.38	1.15	0.27	1.46	0.00	0.00	3.97	0.40	0.00	1.87	7.28	23.16
Fish Creek	Yes	1.68	6.20	7.31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.27	20.45
Fritz Creek	Yes	0.00	0.75	0.00	0.00	0.00	0.00	0.00	0.11	0.00	0.00	1.04	1.45	3.34
Halfway Creek	Yes	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.00	4.76	4.81
Hells Canyon Creek	Yes	0.00	1.65	1.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.49	8.19	11.43
Homestake Creek	No	0.00	0.00	2.30	0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.00	11.18	13.59
Dry Creek	No	0.12	5.07	0.28	0.00	0.38	0.00	0.00	0.51	0.27	0.00	0.00	0.07	6.70
Little Whitetail Creek	No	0.86	5.84	2.07	0.00	0.00	0.00	0.00	1.52	2.49	0.00	0.71	13.90	27.39
Jefferson River-Cardwell	No	1.46	13.65	0.00	0.04	0.79	0.00	0.00	3.32	0.00	0.00	0.86	0.00	20.12
Jefferson River-Cottonwood Creek	No	0.59	2.38	0.00	0.05	0.63	0.22	0.00	2.18	0.39	0.00	0.00	0.00	6.44
Jefferson River-Dry Boulder Creek	No	0.62	3.08	0.50	0.00	0.18	0.00	0.00	2.15	0.96	0.00	0.00	2.27	9.75
Jefferson River-Mill Creek	No	1.11	4.43	3.09	0.05	0.00	0.00	0.00	1.15	0.00	0.00	7.00	7.93	24.75
Jefferson River-Silver Star	No	2.34	2.11	0.89	0.00	0.20	0.00	0.00	0.89	0.43	0.00	0.00	1.08	7.94
Jefferson Slough	No	2.61	9.46	0.00	0.00	0.39	0.00	0.00	2.45	0.00	0.00	0.00	0.00	14.92
Piedmont Swamp	No	4.40	3.24	0.00	0.00	0.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.88
Total Upper Jefferson:		***18.51***	***78.69***	***31.07***	***0.52***	***5.47***	***0.31***	***0.00***	***21.10***	***9.86***	***0.00***	***11.97***	***80.18***	***257.67***

Table 4-6. Estimated Sediment Load From Parallel Segments - Reduce to 500 foot Length

Ownership		Private			State			BLM_USFWS			Forest Service			Total Load Tons/Year
Watershed	1996 / 2004 303(d)	Load (tons/year)			Load (tons/year)			Load (tons/year)			Load (tons/year)			
		Valley	Foothill	Mountain	Valley	Foothill	Mountain	Valley	Foothill	Mountain	Valley	Foothill	Mountain	
Big Pipestone Creek	Yes	1.11	11.77	2.88	0.00	1.33	0.12	0.00	3.03	3.74	0.00	0.00	12.62	36.60
Cherry Creek	Yes	0.00	3.26	1.29	0.00	0.00	0.00	0.00	0.54	0.00	0.00	0.00	0.00	5.08
Dry Boulder Creek	Yes	0.09	0.38	0.39	0.00	0.16	0.00	0.00	0.00	0.65	0.00	0.00	1.29	2.95
Little Pipestone Creek	Yes	1.68	2.64	10.41	0.14	0.00	0.00	0.00	0.00	1.37	0.00	0.00	6.40	22.63
Whitetail Creek	Yes	0.47	7.97	1.39	0.33	1.83	0.00	0.00	4.97	0.48	0.00	2.34	8.80	28.57
Fish Creek	Yes	2.06	7.75	8.83	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.37	25.01
Fritz Creek	Yes	0.00	0.94	0.00	0.00	0.00	0.00	0.00	0.13	0.00	0.00	1.30	1.75	4.12
Halfway Creek	Yes	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.00	0.00	5.75	5.81
Hells Canyon Creek	Yes	0.00	2.06	1.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.61	9.89	13.90
Homestake Creek	No	0.00	0.00	2.78	0.00	0.00	0.00	0.00	0.00	0.13	0.00	0.00	13.51	16.42
Dry Creek	No	0.14	6.34	0.34	0.00	0.47	0.00	0.00	0.64	0.33	0.00	0.00	0.08	8.35
Little Whitetail Creek	No	1.06	7.30	2.50	0.00	0.00	0.00	0.00	1.90	3.01	0.00	0.89	16.80	33.46
Jefferson River-Cardwell	No	1.80	17.06	0.00	0.05	0.98	0.00	0.00	4.15	0.00	0.00	1.08	0.00	25.12
Jefferson River-Cottonwood Creek	No	0.73	2.98	0.00	0.06	0.79	0.26	0.00	2.72	0.47	0.00	0.00	0.00	8.01
Jefferson River-Dry Boulder Creek	No	0.76	3.85	0.61	0.00	0.22	0.00	0.00	2.69	1.15	0.00	0.00	2.74	12.02
Jefferson River-Mill Creek	No	1.36	5.54	3.73	0.06	0.00	0.00	0.00	1.44	0.00	0.00	8.74	9.58	30.46
Jefferson River-Silver Star	No	2.88	2.64	1.07	0.00	0.25	0.00	0.00	1.11	0.52	0.00	0.00	1.30	9.78
Jefferson Slough	No	3.22	11.82	0.00	0.00	0.49	0.00	0.00	3.06	0.00	0.00	0.00	0.00	18.60
Piedmont Swamp	No	5.42	4.05	0.00	0.00	0.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.77
Total Upper Jefferson:		***22.78***	***98.37***	***37.54***	***0.64***	***6.83***	***0.38***	***0.00***	***26.37***	***11.91***	***0.00***	***14.96***	***96.88***	***316.66***

Table 4-7. Total Sediment Load From Unpaved Road Network - Reduce Length to 200-feet

Ownership	1996 / 2004 303(d)	Private			State			BLM_USFWS			Forest Service			Total Load (Tons/Year)
Watershed		Load (tons/year)			Load (tons/year)			Load (tons/year)			Load (tons/year)			
		Valley	Foothill	Mountain	Valley	Foothill	Mountain	Valley	Foothill	Mountain	Valley	Foothill	Mountain	
Big Pipestone Creek	Yes	1.17	13.64	2.95	0.00	1.52	0.10	0.00	3.33	4.02	0.00	0.00	12.46	39.19
Cherry Creek	Yes	0.00	3.78	1.23	0.00	0.00	0.00	0.00	0.62	0.00	0.00	0.00	0.00	5.63
Dry Boulder Creek	Yes	0.12	0.37	0.39	0.00	0.20	0.00	0.00	0.00	0.60	0.00	0.00	1.26	2.93
Little Pipestone Creek	Yes	1.68	2.70	10.00	0.11	0.00	0.00	0.00	0.00	1.26	0.00	0.00	6.19	21.94
Whitetail Creek	Yes	0.60	9.82	1.61	0.31	2.11	0.00	0.00	5.53	0.60	0.00	2.19	8.93	31.72
Fish Creek	Yes	2.26	8.15	8.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.36	24.97
Fritz Creek	Yes	0.00	1.01	0.00	0.00	0.00	0.00	0.00	0.17	0.00	0.00	1.17	1.58	3.93
Halfway Creek	Yes	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.00	0.00	5.48	5.56
Hells Canyon Creek	Yes	0.00	1.91	1.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.56	9.05	12.85
Homestake Creek	No	0.00	0.00	2.76	0.00	0.00	0.00	0.00	0.00	0.14	0.00	0.00	13.23	16.13
Dry Creek	No	0.16	7.61	0.35	0.00	0.77	0.00	0.00	0.58	0.31	0.00	0.00	0.07	9.84
Little Whitetail Creek	No	1.36	8.64	2.46	0.00	0.00	0.00	0.00	2.56	3.02	0.00	1.03	16.97	36.04
Jefferson River-Cardwell	No	1.96	17.29	0.00	0.08	1.11	0.00	0.00	3.52	0.00	0.00	1.12	0.00	25.08
Jefferson River-Cottonwood Creek	No	0.95	3.49	0.00	0.09	0.96	0.22	0.00	2.83	0.42	0.00	0.00	0.00	8.96
Jefferson River-Dry Boulder Creek	No	0.66	4.05	0.57	0.00	0.24	0.00	0.00	2.74	1.15	0.00	0.00	2.66	12.08
Jefferson River-Mill Creek	No	1.47	5.60	3.42	0.10	0.00	0.00	0.00	1.28	0.00	0.00	7.78	9.11	28.75
Jefferson River-Silver Star	No	2.75	3.22	1.02	0.00	0.27	0.00	0.00	1.08	0.46	0.00	0.00	1.18	9.98
Jefferson Slough	No	3.78	12.32	0.00	0.00	0.46	0.00	0.00	3.10	0.00	0.00	0.00	0.00	19.66
Piedmont Swamp	No	5.39	5.06	0.00	0.00	0.43	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.89
Total Upper Jefferson:		***24.31***	***108.66***	***36.28***	***0.70***	***8.07***	***0.31***	***0.00***	***27.34***	***12.07***	***0.00***	***13.85***	***94.53***	***326.12***

Table 4-8. Total Sediment Load From Unpaved Road Network - Reduce Length to 500-feet

Ownership	1996 / 2004 303(d)	Private			State			BLM_USFWS			Forest Service			Total Load (Tons/ Year)
		Load (tons/year)			Load (tons/year)			Load (tons/year)			Load (tons/year)			
Watershed		Valley	Foothill	Mountain	Valley	Foothill	Mountain	Valley	Foothill	Mountain	Valley	Foothill	Mountain	
Big Pipestone Creek	Yes	1.56	29.32	3.95	0.00	3.22	0.12	0.00	6.81	5.51	0.00	0.00	16.47	66.95
Cherry Creek	Yes	0.00	8.12	1.60	0.00	0.00	0.00	0.00	1.35	0.00	0.00	0.00	0.00	11.07
Dry Boulder Creek	Yes	0.16	0.65	0.52	0.00	0.43	0.00	0.00	0.00	0.77	0.00	0.00	1.66	4.20
Little Pipestone Creek	Yes	2.21	5.07	13.05	0.14	0.00	0.00	0.00	0.00	1.62	0.00	0.00	8.10	30.18
Whitetail Creek	Yes	0.84	22.28	2.27	0.41	4.53	0.00	0.00	11.45	0.86	0.00	3.69	11.95	58.27
Fish Creek	Yes	3.04	15.85	10.53	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.45	37.87
Fritz Creek	Yes	0.00	2.02	0.00	0.00	0.00	0.00	0.00	0.40	0.00	0.00	1.84	2.00	6.26
Halfway Creek	Yes	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.12	0.00	0.00	7.13	7.26
Hells Canyon Creek	Yes	0.00	3.14	1.77	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.88	11.53	17.33
Homestake Creek	No	0.00	0.00	3.66	0.00	0.00	0.00	0.00	0.00	0.19	0.00	0.00	17.42	21.27
Dry Creek	No	0.22	16.87	0.47	0.00	2.09	0.00	0.00	0.91	0.39	0.00	0.00	0.08	21.04
Little Whitetail Creek	No	1.88	18.91	3.25	0.00	0.00	0.00	0.00	6.22	4.02	0.00	2.24	22.66	59.18
Jefferson River-Cardwell	No	2.62	32.18	0.00	0.12	2.33	0.00	0.00	4.96	0.00	0.00	2.16	0.00	44.38
Jefferson River-Cottonwood Creek	No	1.33	7.57	0.00	0.13	2.14	0.26	0.00	5.42	0.53	0.00	0.00	0.00	17.39
Jefferson River-Dry Boulder Creek	No	0.84	7.90	0.73	0.00	0.49	0.00	0.00	5.12	1.53	0.00	0.00	3.50	20.10
Jefferson River-Mill Creek	No	1.96	10.40	4.36	0.14	0.00	0.00	0.00	1.98	0.00	0.00	11.98	11.84	42.67
Jefferson River-Silver Star	No	3.56	7.23	1.32	0.00	0.52	0.00	0.00	1.92	0.58	0.00	0.00	1.49	16.63
Jefferson Slough	No	5.17	23.70	0.00	0.00	0.76	0.00	0.00	5.76	0.00	0.00	0.00	0.00	35.40
Piedmont Swamp	No	7.07	11.61	0.00	0.00	1.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	19.79
Total Upper Jefferson:		***32.45***	***222.84***	***47.49***	***0.94***	***17.63***	***0.38***	***0.00***	***52.29***	***16.13***	***0.00***	***22.79***	***124.29***	***537.23***

ATTACHMENT A.
WEPP: ROAD MODELING RESULTS FOR FIELD ASSESSED ROAD CROSSINGS

ID	Yrs	Climate	Soil	Rock	Surface, traffic	Design	Road grad	Road length	Road width	Fill grad	Fill len	Buff grad	Buff len	Precip	Rain runoff	Snow runoff	Sediment Road	Road	Sediment Profile	Profile	Comment	
				%			%	ft	ft	%	ft	%	ft	in	in	in	lb/yr	ton/yr	lb/yr	ton/yr		
1	50	ALDER 17 S MT +	sandy loam	0	native high	insloped bare	11%	138	16	90%	1	3%	1	14.55	0.1	0	163.81	0.082	43.42	0.022	F1-WTC	
2	50	ALDER 17 S MT +	silt loam	0%	native low	outsloped rutted	1%	32	10	35%	1	0.30%	1	14.55	0.24	0.01	3.08	0.002	1.16	0.001	F2-WTC	
3	50	ALDER 17 S MT +	sandy loam	10%	native low	outsloped unrutted	6%	135	9	0.30%	1	0.30%	1	14.55	0.1	0	11.44	0.006	3.32	0.002	F3-WTC	
4	50	ALDER 17 S MT +	sandy loam	40%	native none	outsloped unrutted	9%	380	8	50%	1	0.30%	1	14.55	0.28	0.01	52.98	0.026	24.99	0.012	F4-MWTC	
5	50	ALDER 17 S, MT +	loam	40%	graveled high	outsloped unrutted	9%	295	13	63%	1	0.30%	1	14.55	0.33	0	577.02	0.289	521.46	0.261	F5-MLWTC	
6	50	ALDER 17 S MT +	silt loam	5%	native high	outsloped rutted	5%	540	20	65%	1	0.30%	1	14.55	0.99	0.18	2474.6	1.237	2300.94	1.150	F6-MLWTC	
7	50	ALDER 17 S MT +	loam	40%	native low	outsloped rutted	2%	100	9	0.30%	1	0.30%	1	14.55	0.75	0.18	10.13	0.005	4.67	0.002	F7-MLWTC	
8	50	ALDER 17 S, MT +	silt loam	50%	graveled high	outsloped unrutted	3%	50	11	40%	1	0.30%	1	14.55	0.15	0	15.43	0.008	6.75	0.003	F8-MLWTC	
9	50	PONY MT +	sandy loam	0%	native low	insloped bare	2.50%	285	8	40%	1	3%	1	19.05	0.03	0	20.92	0.010	12.88	0.006	M9-ULWTC	
10	50	ALDER 17 S MT +	sandy loam	0%	native high	insloped bare	2%	1068	24	80%	1	0.30%	1	14.55	0.2	0	415	0.208	417.10	0.209	F10-ULWTC	MULTIPLIED SED. LOADS *2 TO ACCOUNT FOR HALF LENGTH
11	50	PONY MT +	sandy loam	0%	native none	outsloped rutted	4%	123	8	0.30%	1	0.30%	1	19.05	0.18	0.02	9.68	0.005	6.77	0.003	M11-ULWTC	
12	50	PONY, MT +	silt loam	30%	graveled high	outsloped unrutted	5%	330	12	40%	1	5%	1	19.05	0.04	0	195.62	0.098	32.27	0.016	M12-ULWTC	
13	50	PONY MT +	loam	10%	native low	outsloped rutted	5%	153	8	20%	1	0.30%	1	19.05	0.33	0.06	40.62	0.020	30.29	0.015	M13-MLWTC	
14	50	PONY MT +	silt loam	5%	native low	outsloped rutted	3%	375	8	0.30%	1	0.30%	1	19.05	1.29	0.37	77.47	0.039	60.43	0.030	M14-MLWTC	
15	50	PONY, MT +	silt loam	50%	graveled high	outsloped unrutted	3%	150	10	40%	1	0.30%	1	19.05	0.09	0	38.74	0.019	34.96	0.017	M15-MLWTC	

ID	Yrs	Climate	Soil	Rock	Surface, traffic	Design	Road grad	Road length	Road width	Fill grad	Fill len	Buff grad	Buff len	Precip	Rain runoff	Snow runoff	Sediment Road	Road	Sediment Profile	Profile	Comment	
				%			%	ft	ft	%	ft	%	ft	in	in	in	lb/yr	ton/yr	lb/yr	ton/yr		
16	50	ALDER 17 S MT +	sandy loam	20%	native low	outsloped rutted	7%	228	9	62%	1	0.30%	1	14.55	0.39	0.02	48.89	0.024	44.62	0.022	F16-JS	
17	50	ALDER 17 S, MT +	silt loam	30%	graveled high	outsloped unrutted	2%	210	18	90%	1	2%	1	14.55	0.01	0	151.12	0.076	6.06	0.003	F17-JRC	
18	50	ALDER 17 S MT +	silt loam	5%	native high	insloped bare	10%	807	22	60%	1	0.30%	1	14.55	1.15	0.22	12359.16	6.180	10533.33	5.267	F18-JRC	
19	50	TWIN BRIDGES MT +	silt loam	50%	native high	insloped vegetated	1%	237	22	75%	1	0.30%	1	11.5	1.41	0.45	280.6	0.140	206.46	0.103	V19-JS	
20	50	ALDER 17 S, MT +	sandy loam	30%	graveled high	outsloped rutted	4%	366	10	0.30%	1	0.30%	1	14.55	0.55	0.02	220.54	0.110	193.74	0.097	F20-PS	
21	50	TWIN BRIDGES MT +	silt loam	15%	native high	outsloped rutted	0.50%	840	21	50%	1	0.30%	1	11.5	0.85	0.23	439.19	0.220	380.36	0.190	V21-LPC	CHANGED TO OUTSLOPED RUTTED TO ACCOUNT FOR HIGH TRAFFIC, NO CHANGE TO WIDTH
22	50	ALDER 17 S, MT +	sandy loam	0%	native low	outsloped rutted	5%	128	8	0.30%	1	0.30%	1	14.55	0.26	0.01	11.33	0.006	8.82	0.004	F22-LBPC	
23	50	PONY MT +	sandy loam	0%	native low	outsloped rutted	25%	180	10	0.30%	1	0.30%	1	19.05	0.28	0.03	91.11	0.046	68.71	0.034	M23-LBPC	
24	50	PONY MT +	sandy loam	0%	native low	outsloped rutted	5%	90	7	0.30%	1	0.30%	1	19.05	0.18	0.02	5.8	0.003	3.98	0.002	M24-UBPC	
25	50	PONY, MT +	sandy loam	40%	graveled high	insloped bare	4%	735	16	70%	1	10%	1	19.05	0.2	0.01	602.55	0.301	533.58	0.267	M25-UBPC	
26	50	PONY MT +	sandy loam	0%	native none	insloped vegetated	1.50%	321	7	30%	1	0.30%	1	19.05	0.16	0.02	10.11	0.005	7.63	0.004	M26-HC	
27	50	PONY MT +	sandy loam	0%	native low	outsloped rutted	1%	450	8	44%	1	0.30%	1	19.05	0.15	0.02	9.59	0.005	11.26	0.006	M27-UBPC	
28	50	PONY, MT +	sandy loam	30%	graveled high	insloped vegetated	1%	456	24	64%	1	0.30%	1	19.05	0.38	0.02	100.93	0.050	118.10	0.059	M28-UBPC	
29	50	PONY MT +	sandy loam	0%	native low	outsloped rutted	2%	492	12	110%	1	0.30%	1	19.05	0.17	0.03	40.74	0.020	37.82	0.019	M29-HC	
30	50	ALDER 17 S, MT +	silt loam	30%	graveled high	outsloped unrutted	4%	475	17.5	114%	1	0.30%	1	14.55	0.25	0	408.42	0.204	199.97	0.100	F30-LBPC	

ID	Yrs	Climate	Soil	Rock	Surface, traffic	Design	Road grad	Road length	Road width	Fill grad	Fill len	Buff grad	Buff len	Precip	Rain runoff	Snow runoff	Sediment Road	Road	Sediment Profile	Profile	Comment	
				%			%	ft	ft	%	ft	%	ft	in	in	in	lb/yr	ton/yr	lb/yr	ton/yr		
31	50	PONY, MT +	sandy loam	80%	graveled high	outsloped unrutted	2.50%	466	22	80%	1	0.30%	1	19.05	0.15	0	241.55	0.121	190.39	0.095	M31-LPC	
32	50	ALDER 17 S MT +	silt loam	10%	native low	outsloped rutted	2%	297	12	10%	1	0.30%	1	14.55	0.96	0.19	51.86	0.026	41.60	0.021	F32-LPC	
33	50	ALDER 17 S MT +	loam	0%	native none	outsloped rutted	4%	315	8	5%	1	0.30%	1	14.55	1.44	0.3	97.09	0.049	76.62	0.038	F33-FC	
34	50	ALDER 17 S MT +	loam	0%	native none	outsloped rutted	2%	189	8	32%	1	0.30%	1	14.55	0.96	0.19	24.48	0.012	15.97	0.008	F34-FC	
35	50	PONY MT +	sandy loam	15%	native low	outsloped rutted	7%	130	6	0.30%	1	0.30%	1	19.05	0.25	0.03	12.31	0.006	9.07	0.005	M35-HCC	
36	50	PONY, MT +	sandy loam	50%	graveled high	insloped vegetated	9%	201	17	0.30%	1	0.30%	1	19.05	0.4	0.02	180.49	0.090	148.77	0.074	M36-HCC	
37	50	TWIN BRIDGES MT +	silt loam	20%	graveled high	insloped bare	0.50%	593.7	11.5	35%	1	1%	1	11.5	0.29	0.01	379.92	0.190	350.24	0.175	V37-JRCC_1/2L,1/2W	MULTIPLIED SED. LOADS *4 TO ACCOUNT FOR HALF LENGTH + CHANGED WIDTH FROM 22.5 TO 11.25 TO ACCOUNT FOR INSLOPE BARE DITCH FROM CROWNED BARE.

ID	Yrs	Climate	Soil	Rock	Surface, traffic	Design	Road grad	Road length	Road width	Fill grad	Fill len	Buff grad	Buff len	Precip	Rain runoff	Snow runoff	Sediment Road	Road	Sediment Profile	Profile	Comment	
				%			%	ft	ft	%	ft	%	ft	in	in	in	lb/yr	ton/yr	lb/yr	ton/yr		
38	50	ALDER 17 S MT +	silt loam	25%	native high	insloped bare	3%	960	14	12%	1	10%	1	14.55	1.29	0.28	12276.48	6.138	11344.12	5.672	F38-JRCC_ 1/2 W_1/2 L	MULTIPLIED SED. LOADS *4 TO ACCOUNT FOR HALF LENGTH + CHANGED WIDTH FROM 28 TO 14 TO ACCOUNT FOR INSLOPE BARE DITCH FROM CROWNED UNRUTTED.
39	50	PONY MT +	silt loam	30%	native low	outsloped unrutted	9%	478	20	110%	1	0.30%	1	19.05	0.44	0.08	301.14	0.151	169.97	0.085	M39-JRDBC	
40	50	PONY MT +	sandy loam	10%	native low	outsloped rutted	11%	547	18	38%	1	10%	1	19.05	0.32	0.04	447.99	0.224	426.25	0.213	M40-JRMC	CHANGED TO OUTSLOPED RUTTED - CATEGORY INCLUDES INSLOPE RUTTED, NO CHANGE TO WIDTH
41	50	PONY MT +	sandy loam	5%	native none	outsloped rutted	6.50%	183	7.5	0.30%	1	0.30%	1	19.05	0.25	0.03	23.94	0.012	18.64	0.009	M41-JRMC	
42	50	ALDER 17 S MT +	loam	0%	native none	outsloped unrutted	6%	117	7	0.30%	1	0.30%	1	14.55	0.2	0.02	15.57	0.008	1.26	0.001	F42-JRMC	
43	50	PONY MT +	loam	0%	native none	outsloped rutted	8%	150	8	105%	1	0.30%	1	19.05	0.84	0.23	67.58	0.034	40.96	0.020	M43-JRMC	
44	50	PONY MT +	silt loam	70%	native low	outsloped rutted	14%	264	8	110%	1	0.30%	1	19.05	2.82	1.12	586.2	0.293	462.09	0.231	M44-JRSS	
45	50	PONY MT +	sandy loam	25%	native low	outsloped rutted	12%	453	14	0.30%	1	0.30%	1	19.05	0.42	0.05	354.83	0.177	309.71	0.155	M45-JRDBC	
46	50	ALDER 17 S MT +	sandy loam	0%	native low	outsloped unrutted	2%	405	11	115%	1	50%	1	14.55	0.13	0	30.12	0.015	19.72	0.010	F46-JRSS	
47	50	ALDER 17 S MT +	sandy loam	30%	native low	outsloped rutted	5%	519	9	0.30%	1	0.30%	1	14.55	0.4	0.02	115.62	0.058	104.94	0.052	F47-JRDBC	

ID	Yrs	Climate	Soil	Rock	Surface, traffic	Design	Road grad	Road length	Road width	Fill grad	Fill len	Buff grad	Buff len	Precip	Rain runoff	Snow runoff	Sediment Road	Road	Sediment Profile	Profile	Comment	
				%			%	ft	ft	%	ft	%	ft	in	in	in	lb/yr	ton/yr	lb/yr	ton/yr		
48	50	TWIN BRIDGES MT +	silt loam	5%	native high	outsloped rutted	1%	579	18.5	0.30%	1	10%	1	11.5	0.67	0.19	221.63	0.111	191.98	0.096	V48-FC	
49	50	TWIN BRIDGES MT +	silt loam	5%	native high	outsloped rutted	1.50%	480	15	90%	1	2%	1	11.5	0.64	0.17	196.59	0.098	171.65	0.086	V49-FC	
50	50	ALDER 17 S MT +	silt loam	0%	native high	insloped vegetated	2%	470	6	65%	1	0.30%	1	14.55	1.09	0.21	191.18	0.096	157.92	0.079	F50-MWTC, 1/2W,VEG	MULTIPLIED SED. LOADS *2 - CHANGED WIDTH FROM 12 TO 6 TO ACCOUNT FOR INSLOPE VEG DITCH FROM CROWNED UNRUTTED.
51	50	ALDER 17 S MT +	silt loam	0%	native low	outsloped unrutted	1%	29	10.5	72%	1	3%	1	14.55	0.03	0	3.87	0.002	0.34	0.000	F51-MWTC	
52	50	ALDER 17 S MT +	loam	0%	native low	outsloped rutted	3%	60	8.5	0.30%	1	0.30%	1	14.55	0.73	0.14	6.68	0.003	2.72	0.001	F52-MLWTC	
53	50	ALDER 17 S MT +	silt loam	25%	native none	outsloped rutted	13%	447	7	25%	1	3%	1	14.55	0.45	0.06	655.8	0.328	187.46	0.094	F53-MLWTC	
54	50	ALDER 17 S MT +	silt loam	0%	native high	outsloped rutted	6%	598	24	52%	1	0.30%	1	14.55	1.02	0.19	4117.98	2.059	3804.25	1.902	F54-JRC	UNRUTTED CHANGED TO RUTTED TO ACCOUNT FOR HIGH TRAFFIC, NO CHANGE TO WIDTH

ID	Yrs	Climate	Soil	Rock	Surface, traffic	Design	Road grad	Road length	Road width	Fill grad	Fill len	Buff grad	Buff len	Precip	Rain runoff	Snow runoff	Sediment Road	Road	Sediment Profile	Profile	Comment	
				%			%	ft	ft	%	ft	%	ft	in	in	in	lb/yr	ton/yr	lb/yr	ton/yr		
55	50	ALDER 17 S MT +	sandy loam	20%	native high	outsloped unrutted	7%	554	30	78%	1	0.30%	1	14.55	0.34	0.02	3048.68	1.524	2979.26	1.490	F55-PS_1/2L	CROWNED ROAD MODELED AS OUTSLOPE RUTTED. SPLIT ROAD LENGTH IN 1/2 AND DOUBLED SEDIMENT LOAD.
56	50	ALDER 17 S MT +	sandy loam	5%	native low	outsloped rutted	2%	448	10	45%	1	0.30%	1	14.55	0.24	0.01	27.54	0.014	28.25	0.014	F56-PS	
57	50	PONY MT +	sandy loam	10%	native high	outsloped rutted	10%	235	20	116%	1	0.30%	1	19.05	0.33	0.04	426.74	0.213	379.24	0.190	M57-FC	
58	50	PONY MT +	sandy loam	0%	native low	outsloped rutted	10%	507	11	60%	1	35%	1	19.05	0.19	0.02	219.08	0.110	189.31	0.095	M58-FC	
59	50	PONY MT +	sandy loam	25%	native low	outsloped rutted	4%	153	9	80%	1	5%	1	19.05	0.31	0.03	20.16	0.010	18.51	0.009	M59-FC	
60	50	PONY MT +	sandy loam	10%	native low	outsloped rutted	2%	664	8.5	57%	1	20%	1	19.05	0.17	0.03	38.54	0.019	38.48	0.019	M60-FC	

ATTACHMENT B
WEPP: ROAD MODELING RESULTS FOR FIELD ASSESSED PARALLEL ROAD SEGMENTS

ID	Yrs	Climate	Soil	Rock	Surface, traffic	Design	Road grad	Road len	Road width	Fill grad	Fill len	Buff grad	Buff len	Sed road	Road	Normalized Load-Road	Sed profile	Profile	Normalized Load-Profile	Comment	
				%				ft						lb/yr	ton/yr	t/y/1000 ft	lb/yr	ton/yr	load/1000 ft		
2	50	ALDER 17 S MT +	silt loam	0%	native low	outsloped rutted	14%	265	10	40%	265	26%	150	396.3	0.198	0.748	34.14	0.017	0.064	F2P-WTC	Buffer Length >150 ft
5	50	ALDER 17 S, MT +	loam	40%	graveled high	insloped vegetated	9%	723	13	63%	600	30%	13	2173.88	1.087	1.503	1630.02	0.815	1.127	F5P-MLWTC	Modeled as 300ft x 2, 123ft x 1
13	50	PONY MT +	loam	10%	native low	outsloped rutted	5%	705	8	0.30%	1	15%	8	638.05	0.319	0.453	529.48	0.265	0.376	M13P-MLWTC	
14	50	PONY MT +	sandy loam	0%	native low	outsloped rutted	8%	162	8	0.30%	1	16%	41	23.91	0.012	0.074	3.87	0.002	0.012	M14P-MLWTC	
15	50	PONY, MT +	silt loam	50%	graveled high	outsloped rutted	6%	615.5	10	0.30%	1	16%	30	860.3	0.430	0.699	560.44	0.280	0.455	M15P-MLWTC	MULTIPLIED SED. LOADS *2 - HALF LENGTH
17	50	ALDER 17 S, MT +	silt loam	20%	graveled high	outsloped unrutted	3%	594	18	90%	594	9%	55	519.18	0.260	0.437	766.72	0.383	0.645	F17P-JRC	MODEL AS OUTSLOPE RUTTED; 297ft x 2
35	50	PONY MT +	sandy loam	5%	native low	outsloped rutted	7%	1300	6	60%	1300	5%	120	286.6	0.143	0.110	31	0.016	0.012	M35P1-HCC_300 FT LENGTH	Modeled as 300ft x 4, 100ft x 1, Buffer >150ft
35	50	PONY MT +	sandy loam	5%	native low	outsloped rutted	3%	1300	6	0.30%	1	30%	40	75.01	0.038	0.029	64.64	0.032	0.025	M35P2-HCC_300 FT LENGTH	ADD 1000 FT AND 300 FT TO EQUAL TOTAL LENGTH
36	50	PONY MT +	sandy loam	0%	native high	outsloped rutted	12%	162	10	22%	30	2%	87	154.06	0.077	0.475	1.02	0.001	0.003	M36P-HCC	
39	50	PONY MT +	silt loam	30%	native low	outsloped rutted	10%	508	18	55%	508	2%	10	1233.62	0.617	1.214	534.22	0.267	0.526	M39P-JRDBC	Modeled 254ft x 2
40	50	PONY MT +	sandy loam	10%	native low	outsloped rutted	11%	547	18	100%	547	0.30%	1	556.14	0.278	0.508	810.62	0.405	0.741	M40P-JRMC	INSLOPE RUTTED MODELED AS OUTSLOPED RUTTED; Modeled 273.5ft x 2
41	50	PONY MT +	loam	5%	native none	outsloped rutted	3%	108	7.5	0.30%	1	15%	12	15.46	0.008	0.072	5.75	0.003	0.027	M41P-JRMC	
43	50	PONY MT +	sandy loam	10%	native none	outsloped rutted	7%	792	8.5	90%	300	5%	10	363.9	0.182	0.230	599.66	0.300	0.379	M43P-JRMC_HALF LENGTH	Modeled as 792ft x 2
43	50	PONY MT +	sandy loam	50%	native none	outsloped rutted	7%	450	8.5	100%	450	0.30%	1	651.6	0.326	0.724	616.4	0.308	0.685	M43P2-JRMC	Modeled as 300 ft and 150ft

ID	Yrs	Climate	Soil	Rock	Surface, traffic	Design	Road grad	Road len	Road width	Fill grad	Fill len	Buff grad	Buff len	Sed road	Road	Normalized Load-Road	Sed profile	Profile	Normalized Load-Profile	Comment	
44	50	PONY MT +	silt loam	70%	native low	outsloped rutted	16%	490	8	70%	490	20%	1	1357.4	0.679	1.385	1117.6	0.559	1.140	M44P-JRSS	Modeled as 245ft x 2
45	50	PONY MT +	silt loam	25%	native low	outsloped rutted	10%	372	14	0.30%	1	15%	125	240.17	0.120	0.323	16.5	0.008	0.022	M45P-JRDBC	Buffer >150ft
47	50	ALDER 17 S MT +	loam	30%	native low	outsloped rutted	8%	342	9	0.30%	1	15%	40	109.56	0.055	0.160	76.37	0.038	0.112	F47P-JRDBC	
52	50	ALDER 17 S MT +	loam	0%	native low	outsloped rutted	1%	416	9	30%	150	2%	2	36	0.018	0.043	70.89	0.035	0.085	F52P-MLWTC	
56	50	ALDER 17 S MT +	sandy loam	5%	native low	outsloped rutted	1.50%	210	10	0.30%	1	9%	91	8.18	0.004	0.019	0.56	0.000	0.001	F56P-PS	
57	50	PONY MT +	silt loam	10%	native high	outsloped rutted	3%	120	13	92%	120	60%	52	97.42	0.049	0.406	46.37	0.023	0.193	M57P-FC	
57	50	PONY MT +	silt loam	50%	native low	outsloped rutted	12%	507	8	0.30%	1	40%	28	671.65	0.336	0.662	449.96	0.225	0.444	M57P2-FC_HALF LENGTH	MULTIPLIED SED. LOADS *2 - HALF LENGTH
58	50	PONY MT +	sandy loam	5%	native low	insloped vegetated	10%	243	11	74%	243	25%	30	266.43	0.133	0.548	107.24	0.054	0.221	M58P-FC	
58	50	PONY MT +	sandy loam	0%	native low	outsloped rutted	8%	177	8.5	0.30%	1	18%	42	28.65	0.014	0.081	5.67	0.003	0.016	M58P2-FC	

ATTACHMENT C.
FIELD ASSESSMENT SITE GPS DATA

ID	Location ID	Lat	Long	PAR SEG
1	F1-WTC	45.91518208	-112.0490644	0
2	F2-WTC	45.92527633	-112.0315288	1
3	F3-WTC	45.92343164	-112.0536221	0
4	F4-MWTC	45.93153957	-112.0698719	0
5	F5-MLWTC	45.97619298	-112.1141439	1
6	F6-MLWTC	46.0098147	-112.0931726	0
7	F7-MLWTC	46.06674983	-112.1036875	0
8	F8-MLWTC	46.07180285	-112.119477	0
9	M9-ULWTC	46.14575062	-112.1158243	0
10	F10-ULWTC	46.12858461	-112.1131832	0
11	M11-ULWTC	46.08477255	-112.1806855	0
12	M12-ULWTC	46.11091874	-112.175547	0
13	M13-MLWTC	46.04332373	-112.1703007	1
14	M14-MLWTC	46.0664517	-112.167887	1
15	M15-MLWTC	46.07187747	-112.1467756	1
16	F16-JS	45.88011763	-111.9748632	0
17	F17-JRC	45.81786943	-111.9531169	1
18	F18-JRC	45.8453279	-111.9915522	0
19	V19-JS	45.85202048	-112.085201	0
20	F20-PS	45.85156193	-112.142368	0
21	V21-LPC	45.86591241	-112.201216	0
22	F22-LBPC	45.90373052	-112.2027788	0
23	M23-LBPC	45.92310999	-112.268611	0
24	M24-UBPC	45.94527259	-112.2830018	0
25	M25-UBPC	45.95676958	-112.2995419	0
26	M26-HC	45.92383175	-112.3747946	0
27	M27-UBPC	45.95187382	-112.3598012	0
28	M28-UBPC	45.97009126	-112.3560697	0
29	M29-HC	45.94364593	-112.4018914	0
30	F30-LBPC	45.90409753	-112.249963	0
31	M31-LPC	45.8415764	-112.2967477	0
32	F32-LPC	45.86289187	-112.2565829	0
33	F33-FC	45.7745069	-112.3412254	0
34	F34-FC	45.77514114	-112.3430427	0
35	M35-HCC	45.67675894	-112.4211978	2
36	M36-HCC	45.67015188	-112.4077905	1
37	V37-JRCC	45.55598281	-112.3184597	0
38	F38-JRCC	45.59348344	-112.2301355	0
39	M39-JRDBC	45.59714844	-112.1940569	1
40	M40-JRMC	45.70066373	-112.1097823	1

ID	Location ID	Lat	Long	PAR SEG
41	M41-JRMC	45.70494878	-112.0982178	1
42	F42-JRMC	45.69374537	-112.1341411	0
43	M43-JRMC	45.67439851	-112.1316509	2
44	M44-JRSS	45.64655789	-112.1675304	1
45	M45-JRDBC	45.62484573	-112.1885682	1
46	F46-JRSS	45.70145495	-112.2896022	0
47	F47-JRDBC	45.67133469	-112.3079148	1
48	V48-FC	45.79738997	-112.13799	0
49	V49-FC	45.79367607	-112.1551931	0
50	F50-MWTC	45.94658275	-112.1297515	0
51	F51-MWTC	45.9399132	-112.117011	0
52	F52-MLWTC	46.02954732	-112.1177104	1
53	F53-MLWTC	46.02191426	-112.0749703	0
54	F54-JRC	45.82852724	-111.9663031	0
55	F55-PS	45.80635219	-112.2873123	0
56	F56-PS	45.80924211	-112.2540311	1
57	M57-FC	45.81722149	-112.3988044	2
58	M58-FC	45.80075512	-112.400333	2
59	M59-FC	45.78990488	-112.4340641	0
60	M60-FC	45.80882658	-112.454945	0

APPENDIX G
STREAMBANK EROSION SOURCE ASSESSMENT, UPPER JEFFERSON RIVER WATER QUALITY RESTORATION PLANNING AREA

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FIGURES

TABLES

1.0 INTRODUCTION

This report presents an assessment of sediment loading due to streambank erosion along stream segments listed as impaired due to sediment in the Upper Jefferson TMDL Planning Areas (TPA). Sediment loads due to streambank erosion were calculated based on field data collected in 2005. Data collected in the field were extrapolated to the listed stream segments based on the Aerial Assessment Database compiled prior to field data collection. These data were also used to estimate sediment loading at the watershed scale and to assess the potential to decrease sediment inputs due to streambank erosion. The following reports provide further background information used in this assessment:

2004 Aerial Photo Review and Field Source Assessment (MDEQ 2004)

2005 Sediment and Stream Morphology Project, Upper Jefferson (MDEQ 2005)

Streambank Erosion Source Assessment, Middle and Lower Big Hole River Water Quality Restoration Planning Areas (MDEQ 2007)

1.1 Sediment Impairments

Eight segments were listed on the 1996 and 2004 303(d) List for sediment impairments including Big Pipestone, Dry Boulder, Fish, Fitz, Halfway, Hells Canyon, and Little Pipestone creeks along with the Jefferson River. On the 2006 303(d) List, Cherry, Fish, Fitz, Halfway, Hells Canyon, Little Pipestone, and Whitetail creeks, along with the Jefferson River were listed for sedimentation/siltation.

Sediment loading due to streambank erosion was assessed in the field at nineteen locations within the Upper Jefferson watershed. Assessments were performed on Big Pipestone, Cherry, Dry Boulder, Fish, Fitz, Halfway, Hells Canyon, Little Pipestone, and Whitetail creeks along with the Jefferson River.

2.0 DATA COLLECTION AND EXTRAPOLATION

Streambank erosion assessments were performed on 91 streambanks along 19 monitoring sections, a 900 or 20 times bankfull width, whichever is larger, section of a reach where detailed monitoring occurs that represents conditions along a stream reach, covering 10 stream segments, a 303d Listed segment, within the Upper Jefferson TPA. In general, one to three monitoring sections were assessed on each stream segment. Eroding streambank assessments were typically performed along a 900-foot monitoring section, though lengths varied from 630 feet on the smallest streams to approximately 2,500 feet on the Jefferson River. A total of 3.9 miles (20,580 feet) of stream were assessed. Monitoring section locations are presented in **Figure 2-1**.

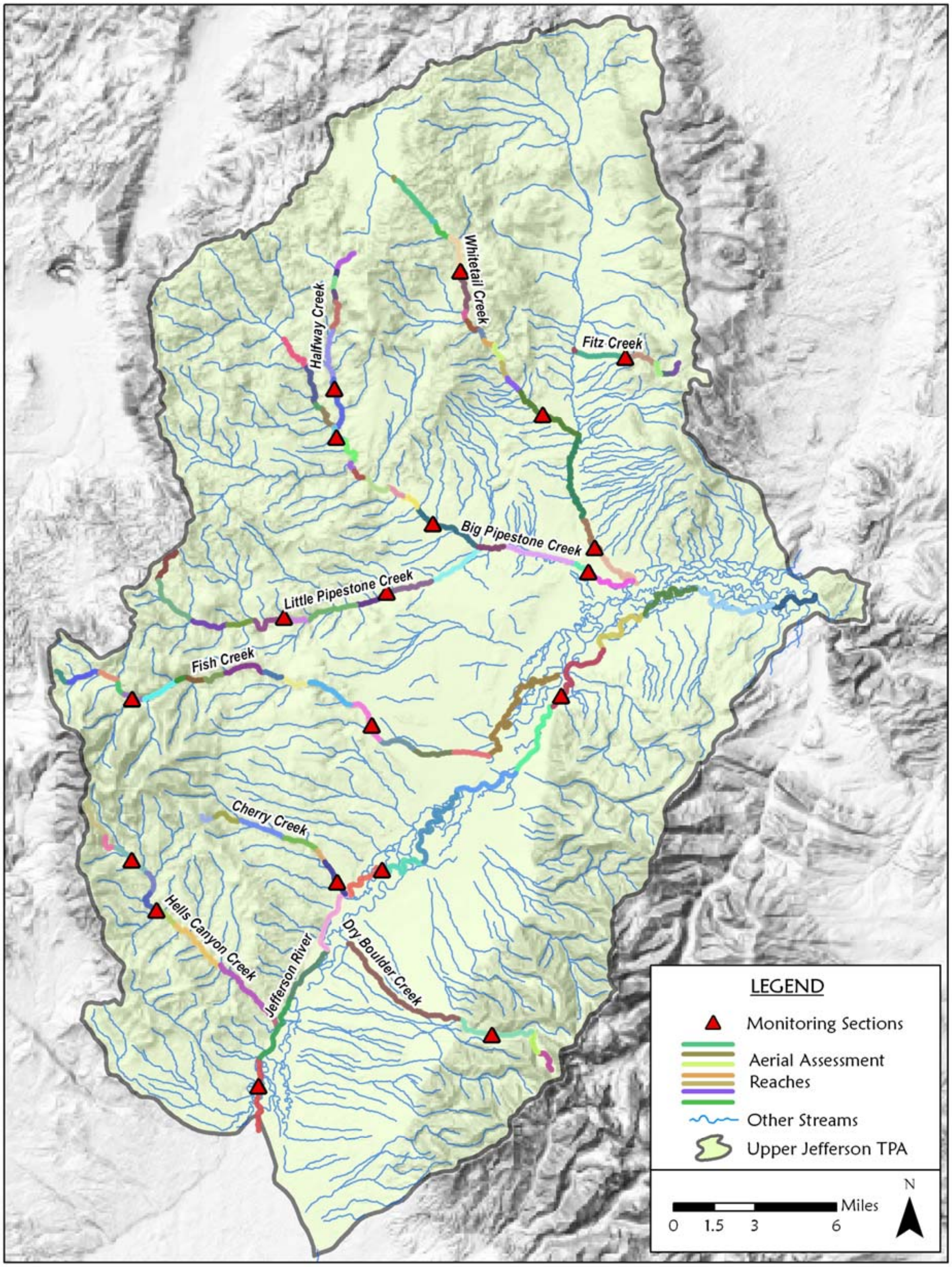

Figure 2-1. Monitoring Sections.

2.1 Field Data Collection

Streambank erosion was assessed by performing Bank Erosion Hazard Index (BEHI) measurements and evaluating the Near Bank Stress (NBS) (Rosgen 1996, 2004). The BEHI score was determined at each eroding streambank based on the following parameters: bank height, bankfull height, root depth, root density, bank angle and surface protection. BEHI categories range from “very low” to “extreme”. At each eroding streambank, the NBS was determined by performing a channel cross-section measurement. The NBS is the ratio of the near-bank maximum bankfull depth (measured as the deepest point in the one-third of the channel closest to the bank) to the bankfull mean depth (Rosgen 2004). NBS categories range from “very low” to “extreme”. The length, height, and composition of each eroding streambank were noted and the source of streambank instability was identified based on the following near-stream source categories:

- Transportation
- Riparian Grazing
- Cropland
- Mining
- Silviculture
- Irrigation-shifts in stream energy
- Natural Sources
- Other

The source of streambank erosion was evaluated based on observed anthropogenic disturbances and the surrounding land-use practices. For example, an eroding streambank in a heavily grazed area in which all the willows had been removed was assigned a source of “100 percent riparian grazing”, while an eroding streambank due to road encroachment upstream was assigned a source of “100 percent transportation”. Naturally eroding streambanks were considered the result of “natural sources”. The “other” category was chosen when streambank erosion resulted from a source not described in the list. If multiple sources were observed, then a percent was noted for each source.

2.2 Estimating Sediment Loads from Field Data

The length of eroding streambank, mean height, and the annual retreat rate were used to determine the annual sediment input from eroding streambanks (in cubic feet). The length and mean height were measured in the field, while the annual retreat rate was determined based on the relationship between BEHI and NBS scores. Streambank retreat rates measured in the Lamar River in Yellowstone National Park (Rosgen 1996) were applied to streambanks in the Upper Jefferson TPA (**Table 2-1**). The annual sediment input in cubic feet was then converted into cubic yards (divided by 27 cubic feet per yard) and finally converted into tons per year based on the bulk density of the streambank to provide an annual sediment load.

Table 2-1. Annual Streambank Retreat Rates (Feet/Year) (adapted from Rosgen 1996).

		Near Bank Stress				
		Very Low	**Low**	**Moderate**	**High**	**Very High**
BEHI	Low	0.019	0.042	0.089	0.19	
	Moderate	0.082	0.17	0.33	0.62	1.3
	High - Very High	0.29	0.44	0.7	1.1	1.7
	Extreme	0.6	0.83	1.3	1.7	2.3

2.3 Streambank Composition

Bulk density of streambanks in Upper Jefferson TPA was determined based on streambank composition data collected in the field and standard soil weights compiled by the U.S Department of the Interior (USDI 1998). Soil weights in the “well-graded” category were selected to most accurately reflect streambank composition, since “well-graded” suggests a wide array of size classes, which is likely what is found in nature. Based on data collected in the 19 monitoring sections, the average streambank composition was 78.95 percent “silt/sand” and 21.05 percent “gravel/cobbles”. This composition most closely resembles the soil group described as “well-graded sand”. Based on the minimum value of the USDI dry unit weight for “well-graded sand”, a value of 107 pounds/foot^3 (1.44 tons/yard^3) was estimated as the average bulk density of streambank material (USDI 1998) (**Table 2-2**). The minimum value was selected to account for plant roots within the streambank that would decrease the overall soil density.

Table 2-2. Streambank Bulk Density (adapted from USDI 1998).

Sample Area	**Sample Size**	**Mean Composition**		**Soil Group**	**Minimum Dry Unit Weight (Pounds/ Foot3)**	**Minimum Dry Unit Weight (Tons/ Yard3)**
		Sand/ Silt (%)	**Gravel/ Cobbles (%)**			
Upper Jefferson Watershed	91	78.95	21.05	Well-graded sand	107	1.44

2.4 Data Extrapolation

Streambank erosion measured along 19 monitoring sections was extrapolated to the stream reach and stream segment scales based on the Aerial Assessment Database. In the field, monitoring sections were selected in areas that were representative of the overall stream condition at the stream reach scale. Sediment loads derived from the monitoring sections were extrapolated to the stream reach scale. Stream reaches were defined in the Aerial Assessment Database prior to field work through the use of GIS data layers and aerial imagery (2004 Aerial Photo Review and Field Source Assessment, MDEQ 2005). Sediment loads extrapolated to the stream reach scale were then summed to achieve an estimate of sediment input due to streambank erosion to each 303(d) listed stream segment. Sediment loading at the watershed scale and the potential to decrease streambank erosion were also estimated. The extrapolation process was outlined in the *Middle and Lower Big Hole TMDL Planning Area Sediment Monitoring Quality Assurance Project Plan* (MDEQ 2005.

3.0 SEDIMENT LOADING DUE TO STREAMBANK EROSION

3.1 Monitoring Section Sediment Loads

Eroding streambank assessments were performed along a total of 3.9 miles of stream in the Upper Jefferson TPA. A total sediment load of 742.4 tons/year was attributed to eroding streambanks within the monitoring sections. Sediment loads due to streambank erosion from these individual monitoring sections ranged from 0.4 tons/year in monitoring section "FITZ-04" to 306.3 tons/year in monitoring section "JEFF-06". A summary of eroding streambank conditions and sediment loading is presented in **Table 3-1**. Sediment loads calculated for each monitoring section were normalized to a length of 1000 feet for the purpose of comparison and extrapolation. Mean BEHI scores, length of eroding bank, percent of eroding bank, and stream type at the laser level cross-section are also presented for each monitoring section in **Table 3-1**.

At the monitoring section scale, 2.8 percent of the bank erosion load was attributed to transportation, 51.1 percent was attributed to riparian grazing, 2.1 percent was attributed to mining, 0.2 percent was attributed to silviculture, 3.3 percent was attributed to irrigation, 33.6 percent was attributed to natural sources, and 6.9 percent was attributed to "other". The "other" source category includes the impacts from reservoirs in the Upper Jefferson TPA. An overall sediment load from eroding streambanks of 438.12 tons/year (59 percent) was attributed to anthropogenic sources, while 304.28 tons/year (41 percent) was attributed to natural sources. Seventy-nine percent (347.2 tons/year) of the anthropogenically induced sediment load is due to streambank erosion on 5 of the monitoring sections (26 percent of the stream length assessed), while the remaining 14 monitoring sections accounted for 21 percent of the anthropogenically induced streambank sediment load. The 5 monitoring sections contributing 80 percent of the anthropogenically derived sediment load included: JEFF-01, JEFF-06, JEFF-10, LPST-09, and WHTL-16. Sediment loads due to streambank erosion for each monitoring section are provided for each source in **Table 3-2**. Note that Corral-1 and Delano-1, from the *Streambank Erosion Source Assessment, Middle and Lower Big Hole River Water Quality Restoration Planning Area*, both Rosgen-type A streams, were used as a reference for Rosgen-type A streams within the Upper Jefferson Water Quality Restoration Planning Area, and therefore, are included in the monitoring section tables.

Table 3-1. Estimated Monitoring Section Sediment Loads due to Streambank Erosion.

Stream	ReachID	Mean BEHI Score	Length of Eroding Bank (feet)	Reach Length (feet)	Percent of Reach with Eroding Bank	Sediment Loading from Monitoring Section (Tons/Year)	Sediment Loading from 1000' of Stream (Tons/Year)	Rosgen Stream Type at Laser Level Cross-section
Big Pipestone Creek	BPST-05	33.3	43	900	2.4%	3.0	6.9	B4
Big Pipestone Creek	BPST-12	64.7	254	900	14.1%	14.3	32.9	C4
Big Pipestone Creek	BPST-15	32.7	244	900	13.6%	22.2	24.7	C5
Cherry Creek	CHRY-06	30.9	52	850	3.1%	4.1	4.8	E5b
Dry Boulder Creek	DRYB-03	26.6	48	900	2.7%	1.5	1.7	B4a
Fish Creek	FISH-05	31.6	18	630	1.4%	1.4	2.2	B3
Fish Creek	FISH-14	32.4	176	900	9.8%	12.6	14.0	B4c
Fitz Creek	FITZ-04	36.1	6	900	0.3%	0.4	0.4	E4a
Halfway Creek	HLWY-07	41.8	129	900	7.2%	27.4	30.5	B4c
Hells Canyon Creek	HELC-03	31.4	151	900	8.4%	3.5	3.9	B4a
Hells Canyon Creek	HELC-06	43.7	13	900	0.7%	1.4	1.5	B4c
Jefferson River	JEFF-01	29.4	1734	1300	66.7%	182.4	140.3	D4 w/in DA4
Jefferson River	JEFF-06	39	2447	2500	48.9%	306.3	122.5	C4
Jefferson River	JEFF-10	33.2	783	900	43.5%	55.7	61.9	C4
Little Pipestone Creek	LPST-06	29.8	32	900	1.8%	3.6	4.0	B4a
Little Pipestone Creek	LPST-09	35.8	253	900	14.1%	55.2	61.0	E4
Whitetail Creek	WHTL-05	30.7	748	900	41.6%	14.8	16.4	B4c
Whitetail Creek	WHTL-14	30.9	230	900	12.8%	7.4	8.2	B4c
Whitetail Creek	WHTL-16	33.3	229	900	12.7%	25.2	27.9	F4
Delano 1 (Big Hole)	Delano 1	15.6	0	900	0.0%	0	0	A4
Corral 1 (Big Hole)	Corral 1	39.3	31	900	1.7%	1.6	1.8	A4

Table 3-2. Monitoring Section Sediment Loads from Individual Sources due to Streambank Erosion.

Stream	Stream Segment	Sources									Total Load
			Transportation	Riparian Grazing	Cropland	Mining	Silviculture	Irrigation - shifts in stream energy	Natural Sources	Other	
Big Pipestone Creek	BPST-05	Tons/Year	0.08	0.60	0.00	0.00	0.00	1.78	0.00	0.53	2.99
		Percent	3%	20%	0%	0%	0%	60%	0%	18%	
Big Pipestone Creek	BPST-12	Tons/Year	0.00	5.19	0.00	0.00	0.00	9.10	0.00	0.00	14.29
		Percent	0%	36%	0%	0%	0%	64%	0%	0%	
Big Pipestone Creek	BPST-15	Tons/Year	0.00	10.72	5.17	0.00	0.00	3.47	2.85	0.00	22.21
		Percent	0%	48%	23%	0%	0%	16%	13%	0%	
Cherry Creek	CHRY-06	Tons/Year	0.00	0.69	0.00	0.00	0.00	0.00	0.42	3.01	4.12
		Percent	0%	17%	0%	0%	0%	0%	10%	73%	
Dry Boulder Creek	DRYB-03	Tons/Year	0.00	0.00	0.00	0.00	0.00	0.00	1.52	0.00	1.52
		Percent	0%	0%	0%	0%	0%	0%	100%	0%	
Fish Creek	FISH-05	Tons/Year	0.14	0.00	0.00	0.00	0.00	0.00	1.25	0.00	1.39
		Percent	10%	0%	0%	0%	0%	0%	90%	0%	
Fish Creek	FISH-14	Tons/Year	0.00	4.00	0.00	0.00	0.00	0.00	7.36	1.27	12.63
		Percent	0%	32%	0%	0%	0%	0%	58%	10%	
Fitz Creek	FITZ-04	Tons/Year	0.00	0.00	0.00	0.00	0.00	0.00	0.37	0.00	0.37
		Percent	0%	0%	0%	0%	0%	0%	100%	0%	
Halfway Creek	HLWY-07	Tons/Year	0.00	17.32	0.00	0.00	0.00	0.00	6.91	3.19	27.42
		Percent	0%	63%	0%	0%	0%	0%	25%	12%	
Hells Canyon Creek	HELC-03	Tons/Year	0.00	3.38	0.00	0.00	0.00	0.00	0.15	0.00	3.53
		Percent	0%	96%	0%	0%	0%	0%	4%	0%	
Hells Canyon Creek	HELC-06	Tons/Year	0.00	0.82	0.00	0.00	0.00	0.00	0.00	0.55	1.37
		Percent	0%	60%	0%	0%	0%	0%	0%	40%	
Jefferson River	JEFF-01	Tons/Year	0.00	0.00	0.00	0.00	0.00	0.00	159.96	22.41	182.37
		Percent	0%	0%	0%	0%	0%	0%	88%	12%	
Jefferson River	JEFF-06	Tons/Year	0.00	0.00	0.00	0.00	0.00	0.00	86.01	220.32	306.33
		Percent	0%	0%	0%	0%	0%	0%	28%	72%	
Jefferson River	JEFF-10	Tons/Year	0.00	0.00	0.00	0.00	0.00	0.00	20.31	35.42	55.73
		Percent	0%	0%	0%	0%	0%	0%	36%	64%	
Little Pipestone Creek	LPST-06	Tons/Year	0.00	0.00	0.00	0.00	0.00	0.00	3.58	0.00	3.58
		Percent	0%	0%	0%	0%	0%	0%	100%	0%	

Table 3-2. Monitoring Section Sediment Loads from Individual Sources due to Streambank Erosion.

Stream	Stream Segment	Sources									Total Load
			Transportation	Riparian Grazing	Cropland	Mining	Silviculture	Irrigation - shifts in stream energy	Natural Sources	Other	
Little Pipestone Creek	LPST-09	Tons/Year	0.00	2.18	0.00	0.00	0.00	0.00	10.11	42.94	55.23
		Percent	0%	4%	0%	0%	0%	0%	18%	78%	
Whitetail Creek	WHTL-05	Tons/Year	0.00	12.79	0.00	0.00	0.00	0.98	0.98	0.00	14.75
		Percent	0%	87%	0%	0%	0%	7%	7%	0%	
Whitetail Creek	WHTL-14	Tons/Year	0.00	5.10	0.00	0.00	0.00	1.04	1.28	0.00	7.42
		Percent	0%	69%	0%	0%	0%	14%	17%	0%	
Whitetail Creek	WHTL-16	Tons/Year	0.00	4.25	0.00	0.00	0.00	9.23	1.22	10.45	25.15
		Percent	0%	17%	0%	0%	0%	37%	5%	42%	
Delano 1 (Big Hole)	Delano 1	Tons/Year	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		Percent	0%	0%	0%	0%	0%	0%	100%	0%	
Corral 1 (Big Hole)	Corral 1	Tons/Year	0.00	0.00	0.00	0.00	0.81	0.00	0.81	0.00	1.62
		Percent	0%	0%	0%	0%	50%	0%	50%	0%	

3.2 Stream Reach Sediment Loads

Sediment loads calculated at the monitoring section scale were extrapolated to the aerial assessment stream reach and stream segment scales. The monitoring section sediment load was extrapolated directly to the stream reach in which it was located. Stream reaches in which no monitoring section was located were assigned a sediment load due to streambank erosion based on the most similar monitoring section. This decision was based on several factors including the existing and potential stream type, valley type, the surrounding landscape, land-use practices, information in the Aerial Assessment Database, a review of 2005 color aerial imagery in GIS, and best professional judgment based on site-specific knowledge acquired during the monitoring section assessment process.

Sources of sediment due to streambank erosion at the stream reach and stream segment scales were determined based on monitoring section data and the Aerial Assessment Database. Sources of streambank erosion at the monitoring section scale were assigned directly to the aerial assessment reach in which they occurred. Sources of sediment to stream reaches in which no monitoring section was located were evaluated using the Aerial Assessment Database, which included information for “prominent land use”, “indictors of potential degradation”, and “potential sources of potential degradation”. Additional information regarding these parameters can be found in the *2004 Aerial Photo Review and Field Source Assessment, Upper Jefferson Watershed* (MDEQ 2004) and the *2005 Sediment and Stream Morphology Project* (MDEQ 2006). A review of color aerial imagery from 2005 and on-the-ground knowledge gained during the assessment process were used as supporting information when assigning sediment sources.

For aerial assessment stream reaches in which no monitoring section was located, 10 to 100% of the sediment load was considered to be the result of natural sediment erosion, the percentage dependent upon anthropogenic sediment sources noted in the 2004 Aerial Assessment or visual sources located on the 2005 NAIP imagery used. Anthropogenic sediment loads along the non-monitored sections were estimated to be 5-20% for reaches with transporation associated sediment and determined by the location and concentration of the road system adjacent to the reach, 20-40% for grazing, cropland, and shifts in stream energy in which the percentage was developed based on the monitoring section values. Mining was given 30% based on the presence of mine features within the 2005 NAIP imagery and if a mine was noted in the 2004 Aerial Assessment, along with on the ground knowledge. This process was performed individually for each reach, with sediment loads assigned to each observed source based on the overall estimated reach load. Thus, sources of sediment in reaches with low overall sediment loads accounted for less of the total sediment load at the reach scale than sources of sediment in reaches with high sediment loads. When no anthropogenic sources were indicated in the aerial assessment database, 100% of the estimated sediment load was considered natural. Data extrapolated to the stream reach scale is presented in the Streambank Erosion Database in **Attachment A**. This database is an extension of the Aerial Assessment Database prepared prior to field data collection.

3.3 Stream Segment Sediment Loads

Sediment loads were extrapolated to 157.5 miles of listed stream segments based on stream reaches defined in the Aerial Assessment Database. Sediment loads extrapolated from the monitoring sections scale to the stream reaches scale were summed to obtain a sediment load for each stream segment (**Attachment A**). A total estimated sediment load of 28,795 tons/year was attributed to eroding streambanks on the assessed stream segments. Estimated sediment loads for 303(d) listed stream segments ranged from 28.9 tons/year or 1.52 tons/year per 1000 feet for Fitz Creek to 16,094 tons/year or 73.45 tons/year per 1000 feet for the Jefferson River. At the stream segment scale, 6.1% of the bank erosion was attributed to transportation, 11.0% was attributed to riparian grazing, 16.4% was attributed to cropland, 1.5% was attributed to mining, 18.9% was attributed to irrigation, 35.2% was attributed to natural sources and 10.9% was attributed to "other". An overall sediment load of 18,651.76 tons/year (64.8%) from eroding banks was attributed to anthropogenic sources, while 10,146.02 tons/year (35.2%) were attributed to natural sources. Sediment loads due to streambank erosion for each stream segment are provided for each source in **Table 3-3**.

Table 3-3. Stream Segment Sediment Loads from Individual Sources due to Streambank Erosion.

Stream Segment	Stream Segment Length (Miles)	Sediment Load	Sources								Total Load	Load per mile	Load per 1000 feet
			Transportation	Riparian Grazing	Cropland	Mining	Silviculture	Irrigation - shifts in stream energy	Natural Sources	Other			
Big Pipestone Creek	17.1	Tons/Year	188.74	638.22	247.04	21.15	0.00	685.80	344.56	35.16	2160.7	126.35	23.93
		Percent	8.74%	29.54%	11.43%	0.98%	0.00%	31.74%	15.95%	1.63%			
Cherry Creek	6.4	Tons/Year	2.71	26.45	0.00	0.00	0.00	27.02	54.64	0.00	110.8	17.32	3.28
		Percent	2.45%	23.87%	0.00%	0.00%	0.00%	24.38%	49.30%	0.00%			
Dry Boulder Creek	8.8	Tons/Year	2.43	12.90	0.00	1.14	0.00	12.90	48.79	0.00	78.2	8.88	1.68
		Percent	3.11%	16.50%	0.00%	1.46%	0.00%	16.50%	62.43%	0.00%			
Fish Creek	23.9	Tons/Year	154.89	317.81	136.97	3.14	0.00	233.53	678.81	15.32	1540.5	64.45	12.21
		Percent	10.05%	20.63%	8.89%	0.20%	0.00%	15.16%	44.07%	0.99%			
Fitz Creek	3.6	Tons/Year	1.56	6.40	0.00	0.00	0.00	3.58	17.34	0.00	28.9	8.03	1.52
		Percent	5.41%	22.17%	0.00%	0.00%	0.00%	12.38%	60.04%	0.00%			
Hells Canyon Creek	10.9	Tons/Year	2.93	34.78	0.00	0.00	0.00	6.99	65.54	3.07	113.3	10.39	1.97
		Percent	2.59%	30.70%	0.00%	0.00%	0.00%	6.17%	57.84%	2.71%			
Halfway Creek	7.4	Tons/Year	3.30	133.70	0.00	0.00	0.00	0.00	537.52	10.76	685.3	92.61	17.54
		Percent	0.48%	19.51%	0.00%	0.00%	0.00%	0.00%	78.44%	1.57%			
Jefferson River	41.5	Tons/Year	578.06	384.14	3356.42	400.72	0.00	3357.04	5671.36	2346.23	16094.0	387.81	73.45
		Percent	3.59%	2.39%	20.86%	2.49%	0.00%	20.86%	35.24%	14.58%			
Little Pipestone Creek	16.2	Tons/Year	548.44	711.52	504.19	0.00	0.00	374.96	1652.52	600.47	4392.1	271.12	51.35
		Percent	12.49%	16.20%	11.48%	0.00%	0.00%	8.54%	37.62%	13.67%			
Whitetail Creek	21.6	Tons/Year	270.92	894.83	481.08	0.00	0.00	736.21	1071.92	136.16	3591.1	166.26	31.49
		Percent	7.54%	24.92%	13.40%	0.00%	0.00%	20.50%	29.85%	3.79%			

3.4 Watershed Sediment Loads

Based on a modified version of the USGS National Hydrography Dataset (NHD) in which irrigation ditches were removed, there are 1,458.83 miles of stream in the Upper Jefferson TPA, (**Table 3-4**). Sediment loads due to eroding streambanks were calculated along 3.9 miles of monitoring section and extrapolated to 157.5 miles of listed stream segments, leaving 1301.3 miles of stream unassessed.

Sediment input along the 1,301.3 miles of unassessed streams was evaluated using the 25th percentile of sediment loading from the entire dataset. Based on the 25th percentile of the entire dataset at the stream segment scale, an annual sediment load of 12.1 tons/mile was estimated to be the natural background rate of streambank erosion within the Upper Jefferson TPA. This value is equivalent to 3.95 tons/year of sediment input from every 1000 feet of stream. The 25th percentile for streambank erosion at the monitoring section scale (1000 conversion) was also reviewed, resulting in a value of 2.5 tons/year. The use of the 25th percentile accounts for the likelihood of 1st order tributaries in the watershed contributing little or no sediment due to streambank erosion, while 2nd-4th order tributaries in the watershed likely contribute similar amounts of sediment due to streambank erosion as the assessed segments, from which a median sediment load of 14.87 tons/year per 1000 feet was measured. Thus, an annual background erosion rate of approximately 2-2.5 tons per 1000 feet of stream is thought to be appropriate for streams in the Upper Jefferson TPA. A total estimated sediment load of 44,576.3 tons/year was attributed to eroding streambanks within the Upper Jefferson TPA. Streambank erosion sediment loads and sources at the watershed scale for assessed stream segments are presented in **Table 3-5**.

Table 3-4. Summary of Sediment Loads due to Streambank Erosion at the Watershed Scale.

TMDL Planning Area	Stream Length (Miles)	Length of Stream Assessed using Aerial Imagery (Miles)	Length of Stream Unassessed (Miles)	Estimated Sediment Load for Assessed Streams	Estimated Sediment Load for Unassessed Streams based on Stream Segment Extrapolation (12.13 Tons/Mile/Year)	Total Sediment Load
Upper Jefferson	1458.83	157.5	1301.03	28,794.80	15,781.5	44,576.3

Table 3-5. Watershed Sediment Loads from Individual Sources due to Streambank Erosion.

Stream Segment	Total Stream Length with Watershed based on NHD (Miles)	Sediment Load	Sources								Total Load
			Transportation	Riparian Grazing	Cropland	Mining	Silviculture	Irrigation - shifts in stream energy	Natural Sources	Other	
Big Pipestone Creek	219.2	Tons/Year	961.37	1925.95	975.32	27.46	0.00	1377.19	3290.68	839.21	9,397.24
		Percent	0.10	0.20	0.10	0.00	0.00	0.15	0.35	0.09	
Cherry Creek	26.6	Tons/Year	8.71	84.88	0.00	0.00	0.00	86.70	175.32	0.00	355.60
		Percent	0.02	0.24	0.00	0.00	0.00	0.24	0.49	0.00	
Dry Boulder Creek	22.1	Tons/Year	7.46	39.51	0.00	3.49	0.00	39.51	149.49	0.00	239.45
		Percent	0.03	0.17	0.00	0.01	0.00	0.17	0.62	0.00	
Fish Creek	94.5	Tons/Year	240.82	494.12	212.96	4.88	0.00	363.08	1,055.41	23.82	2,395.09
		Percent	0.10	0.21	0.09	0.00	0.00	0.15	0.44	0.01	
Fitz Creek	7.8	Tons/Year	4.32	17.73	0.00	0.00	0.00	9.90	48.00	0.00	79.95
		Percent	0.05	0.22	0.00	0.00	0.00	0.12	0.60	0.00	
Hells Canyon Creek	61.6	Tons/Year	18.81	223.16	0.00	0.00	0.00	44.86	420.52	19.67	727.02
		Percent	0.03	0.31	0.00	0.00	0.00	0.06	0.58	0.03	
Halfway Creek	15.5	Tons/Year	3.77	152.80	0.00	0.00	0.00	0.00	614.30	12.30	783.17
		Percent	0.00	0.20	0.00	0.00	0.00	0.00	0.78	0.02	
Jefferson River	1458.8	Tons/Year	1,194.04	793.48	6,933.01	827.74	0.00	6,934.29	11,714.75	4,846.36	33,243.67
		Percent	0.04	0.02	0.21	0.02	0.00	0.21	0.35	0.15	
Little Pipestone Creek	81	Tons/Year	646.31	838.51	594.17	0.00	0.00	441.88	1,947.44	707.63	5,175.94
		Percent	0.12	0.16	0.11	0.00	0.00	0.09	0.38	0.14	
Whitetail Creek	272.2	Tons/Year	499.65	1,650.28	887.22	0.00	0.00	1,357.76	1,976.88	251.11	6,622.89
		Percent	0.08	0.25	0.13	0.00	0.00	0.21	0.30	0.04	

4.0 POTENTIAL SEDIMENT LOAD REDUCTION

This section is provided for technical guidance in determining sediment allocations for human influenced activities that cause streambank erosion. The results are only one of a number of components that will be considered during the TMDL sediment allocation process. The results are provided to determine a reasonable amount of sediment reduction to sources that influence streambank erosion. The allocation process will also consider economic feasibility of restoration from each significant source and regional BMP effectiveness studies. Determining a potential overall load reduction from streambank erosion also will help define how much sediment production from streambank erosion is likely derived from natural conditions.

4.1 Reference Condition

The Beaverhead-Deerlodge National Forest (BDNF) reference dataset indicates that a “moderate” BEHI score (20-29.5) can be expected on reference streams with the following stream types: A, C, (C3, C4) and E (E3, E4, E5, Ea) (**Table 4-1**) (Bengeyfield 2004). Streams classified as B stream types are on the border of the “moderate” and “high” (30.0-39.5) BEHI categories, with B3 streams falling in “moderate” category and B4 streams falling in the “high” category. Based on the BDNF reference dataset, it was determined that functioning streams in the Upper Jefferson TPA would tend to have a “moderate” BEHI score.

To estimate a potential decrease in sediment loading due to improved streambank stability, BEHI values in the existing dataset that exceeded the “moderate” category were reduced to “moderate”. The results of this model are presented in **Table 4-2** for the individual monitoring sections. Reductions calculated at the monitoring section scale were extrapolated to the stream segment scale using the Aerial Assessment Database (**Table 4-3**). This reduction often resulted in a “moderate BEHI/low NBS” combination for an expected retreat rate of 0.17 tons/year. Through BMPs, the actual length and height of eroding bank could also be reduced, which would lead to further reductions in sediment loading.

Table 4-1. Expected BEHI Values for Various Stream Types based on the BDNF Reference Dataset.

A	B3	B4	B	C3	C4	C	E3	E4	E5	Ea	E
24.2	27.1	31.7	29.7	26.9	26.5	26.5	26.3	24.2	22	22.7	23.6

Table 4-2. Monitoring Section Sediment Loads with BEHI Reduced to "Moderate".

Stream	ReachID	Sediment Loading from Monitoring Section (Tons/Year)	Sediment Loading from 1000' of Stream (Tons/Year)	Sediment Loading from Monitoring Section with Moderate BEHI (Tons/Year)	Sediment Loading from 1000' of Stream with Moderate BEHI (Tons/Year)
Big Pipestone Creek	BPST-05	2.99	6.89	1.55	1.72
Big Pipestone Creek	BPST-12	14.29	32.92	4.72	5.24
Big Pipestone Creek	BPST-15	22.21	24.67	11.33	12.59
Cherry Creek	CHRY-06	4.11	4.84	2.29	2.69
Dry Boulder Creek	DRYB-03	1.52	1.68	1.32	1.47
Fish Creek	FISH-05	1.39	2.21	0.54	0.86
Fish Creek	FISH-14	12.63	14.03	5.85	6.50
Fitz Creek	FITZ-04	0.37	0.41	0.37	0.41
Halfway Creek	HLWY-07	27.41	30.46	6.17	6.86
Hells Canyon Creek	HELC-03	3.53	3.92	1.00	1.11
Hells Canyon Creek	HELC-06	1.37	1.53	0.53	0.59
Jefferson River	JEFF-01	182.37	140.29	109.03	83.87
Jefferson River	JEFF-06	306.33	122.53	109.36	43.74
Jefferson River	JEFF-10	55.73	61.92	15.76	17.51
Little Pipestone Creek	LPST-06	3.58	3.98	1.69	1.88
Little Pipestone Creek	LPST-09	55.23	61.01	22.68	25.20
Whitetail Creek	WHTL-05	14.75	16.39	7.71	8.57
Whitetail Creek	WHTL-14	7.42	8.25	4.77	5.30
Whitetail Creek	WHTL-16	25.15	27.95	12.29	13.66
Delano 1 (Big Hole)	Delano 1	0.00	0.00	0.00	0.00
Corral 1 (Big Hole)	Corral 1	1.61	1.79	0.62	0.69

Table 4-3. Potential Sediment Load Reduction from Stream Segments with BEHI Reduced to "Moderate".

Stream Segment	Total Load (Tons/ Year)	Total Load with "Moderate " BEHI (Tons/ Year)	Total Load due to Anthropogenic Sources (Tons/Year)	Total Load with "Moderate" BEHI due to Anthropogenic Sources (Tons/Year)	Potential Reduction in Anthropogenic Sediment Load with "Moderate" BEHI (Tons/Year)	Percent Reduction in Anthropogenic Sediment Load with "Moderate" BEHI
Big Pipestone Creek	2160.66	707.59	1816.10	603.4	1212.7	67%
Cherry Creek	110.82	40.63	56.18	18.7	37.5	67%
Dry Boulder Creek	78.16	68.39	29.37	25.7	3.7	13%
Fish Creek	1540.47	710.59	861.66	398.4	463.3	54%
Fitz Creek	25.50	20.29	10.19	9.3	0.9	9%
Hells Canyon Creek	113.30	39.72	47.77	15.9	31.9	67%
Halfway Creek	221.57	215.81	87.79	69.1	18.7	21%
Jefferson River	16093.98	7890.10	10422.61	4984.7	5437.9	52%
Little Pipestone Creek	4392.10	1555.22	2739.58	1080.0	1659.6	61%
Whitetail Creek	3591.12	1532.28	2519.20	1085.8	1433.4	57%

5.0 REFERENCES

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ATTACHMENT A
STREAMBANK EROSION DATABASE, UPPER JEFFERSON RIVER TMDL PLANNING AREA

Stream	Reach	Sinuosity	Valley Slope	Channel Slope	Rosgen Classification	Most Similar Stream Section used for Modeling Sediment Loading (Monitoring Sections in Bold)	Sediment Load due to Bank Erosion per 1000 Feet (Tons/ Year)	Sediment Load due to Bank Erosion per Mile (Tons/ Year)	Aerial Assessment Reach Length (Miles)	Sediment Load due to Bank Erosion for Entire Aerial Assessment	Sediment Source (Percent)								Sediment Load by Sediment Source (Tons/Year)							
											Transportation	Riparian grazing	Cropland	Mining	Silviculture	Irrigation - shifts in stream energy	Natural sources	Other	Transportation	Riparian grazing	Cropland	Mining	Silviculture	Irrigation - shifts in stream energy	Natural sources	Other
Big Pipestone Creek	BPST-01	1.29	0.064	0.05	C	BPST-05	6.89	36.38	1.35	49.22	5%						65%	30%	2.46	0.00	0.00	0.00	0.00	0.00	31.99	14.76
Big Pipestone Creek	BPST-02	1.16	0.068	0.059	B	BPST-05	6.89	36.38	1.17	42.70	5%			30%			65%		2.13	0.00	0.00	12.81	0.00	0.00	27.75	0.00
Big Pipestone Creek	BPST-03	1.3	0.023	0.018	C	BPST-05	6.89	36.38	0.32	11.61							100%		0.00	0.00	0.00	0.00	0.00	0.00	11.61	0.00
Big Pipestone Creek	BPST-04	1.35	0.059	0.044	B	BPST-05	6.89	36.38	0.76	27.79				30%			70%		0.00	0.00	0.00	8.34	0.00	0.00	19.45	0.00
Big Pipestone Creek	BPST-05	1.35	0.028	0.021	B4	BPST-05	6.89	36.38	0.69	25.27	2%	20%				60%		18%	0.51	5.05	0.00	0.00	0.00	15.16	0.00	4.55
Big Pipestone Creek	BPST-06	1.67	0.064	0.038	B	BPST-05	6.89	36.38	0.95	34.69							100%		0.00	0.00	0.00	0.00	0.00	0.00	34.69	0.00
Big Pipestone Creek	BPST-07	1.42	0.04	0.028	C	BPST-12	32.92	173.82	0.30	52.97							100%		0.00	0.00	0.00	0.00	0.00	0.00	52.97	0.00
Big Pipestone Creek	BPST-08	1.16	0.079	0.068	B	BPST-05	6.89	36.38	0.29	10.68	10%						90%		1.07	0.00	0.00	0.00	0.00	0.00	9.61	0.00
Big Pipestone Creek	BPST-09	1.17	0.025	0.021	C	BPST-12	32.92	173.82	1.05	183.20	10%	35%				40%	15%		18.32	64.12	0.00	0.00	0.00	73.28	27.48	0.00
Big Pipestone Creek	BPST-10	1.23	0.01	0.008	C	BPST-12	32.92	173.82	0.69	119.80	15%	30%	20%			25%	10%		17.97	35.94	23.96	0.00	0.00	29.95	11.98	0.00
Big Pipestone Creek	BPST-11	1.35	0.008	0.006	E	LPST-09	61.01	322.13	0.77	248.31	15%	30%	20%			25%	10%		37.25	74.49	49.66	0.00	0.00	62.08	24.83	0.00
Big Pipestone Creek	BPST-12	1.27	0.008	0.006	C4	BPST-12	32.92	173.82	2.91	505.65		36%				64%			0.00	182.03	0.00	0.00	0.00	323.62	0.00	0.00
Big Pipestone Creek	BPST-13	1.33	0.005	0.004	F	WHTL-16	27.95	147.58	1.08	159.51	15%	30%	20%			25%	10%		23.93	47.85	31.90	0.00	0.00	39.88	15.95	0.00
Big Pipestone Creek	BPST-14	1.07	0.005	0.005	F	WHTL-16	27.95	147.58	2.26	333.00	15%	30%	20%			25%	10%		49.95	99.90	66.60	0.00	0.00	83.25	33.30	0.00
Big Pipestone Creek	BPST-15	1.23	0.004	0.003	C5	BPST-15	24.67	130.26	0.94	121.92		48%	23%				16%	13%	0.00	58.52	28.04	0.00	0.00	0.00	19.51	15.85
Big Pipestone Creek	BPST-16	1.25	0.004	0.003	F	WHTL-16	27.95	147.58	1.59	234.36	15%	30%	20%			25%	10%		35.15	70.31	46.87	0.00	0.00	58.59	23.44	0.00
Cherry Creek	CHRY-01	1.02	0.297	0.291	A+	Corral-1 (Big Hole)	1.79	9.45	0.51	4.77							100%		0.00	0.00	0.00	0.00	0.00	0.00	4.77	0.00
Cherry Creek	CHRY-02	1.04	0.139	0.134	A	Delano-1 (Big Hole)	0.00	0.00	1.08	0.00	10%						90%		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cherry Creek	CHRY-03	1.15	0.075	0.065	B	HELC-03	3.92	20.70	1.76	36.33		33%				33%	34%		0.00	11.99	0.00	0.00	0.00	11.99	12.35	0.00
Cherry Creek	CHRY-04	1.12	0.068	0.061	B	HELC-03	3.92	20.70	1.31	27.13	10%					40%	50%		2.71	0.00	0.00	0.00	0.00	10.85	13.57	0.00
Cherry Creek	CHRY-05	1.14	0.043	0.038	B	HELC-06	3.92	20.70	0.50	10.44		40%				40%	20%		0.00	4.18	0.00	0.00	0.00	4.18	2.09	0.00
Cherry Creek	CHRY-06	1.09	0.05	0.046	E5b	CHRY-06	4.84	25.56	1.26	32.14		32%					68%		0.00	10.29	0.00	0.00	0.00	0.00	21.86	0.00
Dry Boulder	DRYB-01	1.13	0.15	0.133	C	DRYB-03	1.68	8.87	0.64	5.69	5%			20%			75%		0.28	0.00	0.00	1.14	0.00	0.00	4.27	0.00
Dry Boulder	DRYB-02	1.19	0.107	0.09	B	DRYB-03	1.68	8.87	0.88	7.84							100%		0.00	0.00	0.00	0.00	0.00	0.00	7.84	0.00
Dry Boulder	DRYB-03	1.05	0.166	0.158	B4a	DRYB-03	1.68	8.87	2.44	21.64							100%		0.00	0.00	0.00	0.00	0.00	0.00	21.64	0.00
Dry Boulder	DRYB-04	1.07	0.063	0.059	B	DRYB-03	1.68	8.87	4.85	42.99	5%	30%				30%	35%		2.15	12.90	0.00	0.00	0.00	12.90	15.05	0.00
Fish Creek	FISH-01	1.1	0.139	0.126	A+	Corral-1 (Big Hole)	1.79	9.45	0.59	5.60	5%			20%			75%		0.28	0.00	0.00	1.12	0.00	0.00	4.20	0.00
Fish Creek	FISH-02	1.08	0.068	0.063	G	FISH-05	2.21	11.67	0.97	11.26	15%						85%		1.69	0.00	0.00	0.00	0.00	0.00	9.57	0.00
Fish Creek	FISH-03	1.11	0.037	0.033	G	FISH-05	2.21	11.67	0.65	7.59	15%	20%					65%		1.14	1.52	0.00	0.00	0.00	0.00	4.93	0.00
Fish Creek	FISH-04	1.11	0.075	0.068	B	FISH-05	2.21	11.67	0.43	5.04	20%	20%		40%			20%		1.01	1.01	0.00	2.02	0.00	0.00	1.01	0.00
Fish Creek	FISH-05	1.07	0.114	0.107	B3	FISH-05	2.21	11.67	0.67	7.76	10%						90%		0.78	0.00	0.00	0.00	0.00	0.00	6.99	0.00
Fish Creek	FISH-06	1.16	0.034	0.029	C	FISH-14	14.03	74.08	1.29	95.81	15%	20%					65%		14.37	19.16	0.00	0.00	0.00	0.00	62.28	0.00
Fish Creek	FISH-07	1.06	0.036	0.034	B	FISH-05	2.21	11.67	0.36	4.24	10%						90%		0.42	0.00	0.00	0.00	0.00	0.00	3.81	0.00
Fish Creek	FISH-08	1.16	0.044	0.038	C	FISH-14	14.03	74.08	0.63	46.59	10%						90%		4.66	0.00	0.00	0.00	0.00	0.00	41.93	0.00
Fish Creek	FISH-09	1.09	0.032	0.029	B	FISH-14	14.03	74.08	0.71	52.26							100%		0.00	0.00	0.00	0.00	0.00	0.00	52.26	0.00
Fish Creek	FISH-10	1.12	0.037	0.033	C	FISH-14	14.03	74.08	1.35	99.96	10%	30%					60%		10.00	29.99	0.00	0.00	0.00	0.00	59.98	0.00
Fish Creek	FISH-11	1.06	0.053	0.005	B	FISH-14	14.03	74.08	0.49	36.52							100%		0.00	0.00	0.00	0.00	0.00	0.00	36.52	0.00
Fish Creek	FISH-12	1.22	0.032	0.026	C	FISH-14	14.03	74.08	1.23	91.46	15%	20%	20%			25%	20%		13.72	18.29	18.29	0.00	0.00	22.87	18.29	0.00
Fish Creek	FISH-13	1.09	0.037	0.034	B	FISH-14	14.03	74.08	1.75	129.43							100%		0.00	0.00	0.00	0.00	0.00	0.00	129.43	0.00

Stream	Reach	Sinuosity	Valley Slope	Channel Slope	Rosgen Classification	Most Similar Stream Section used for Modeling Sediment Loading (Monitoring Sections in Bold)	Sediment Load due to Bank Erosion per 1000 Feet (Tons/ Year)	Sediment Load due to Bank Erosion per Mile (Tons/ Year)	Aerial Assessment Reach Length (Miles)	Sediment Load due to Bank Erosion for Entire Aerial Assessment	Sediment Source (Percent)								Sediment Load by Sediment Source (Tons/Year)							
											Transportation	Riparian grazing	Cropland	Mining	Silviculture	Irrigation - shifts in stream energy	Natural sources	Other	Transportation	Riparian grazing	Cropland	Mining	Silviculture	Irrigation - shifts in stream energy	Natural sources	Other
Fish Creek	FISH-14	1.19	0.021	0.018	B4c	FISH-14	14.03	74.08	2.07	153.22		32%					58%	10%	0.00	49.03	0.00	0.00	0.00	0.00	88.87	15.32
Fish Creek	FISH-15	1.27	0.022	0.017	C	FISH-14	14.03	74.08	1.27	93.89	15%	20%	20%			25%	20%		14.08	18.78	18.78	0.00	0.00	23.47	18.78	0.00
Fish Creek	FISH-16	1.11	0.032	0.029	C	FISH-14	14.03	74.08	1.50	111.24		40%				40%	20%		0.00	44.50	0.00	0.00	0.00	44.50	22.25	0.00
Fish Creek	FISH-17	1.09	0.008	0.007	G	FISH-14	14.03	74.08	1.20	89.08	20%	40%				20%	20%		17.82	35.63	0.00	0.00	0.00	17.82	17.82	0.00
Fish Creek	FISH-18	not classified in AA				FISH-14	14.03	74.08	6.74	499.51	15%	20%	20%			25%	20%		74.93	99.90	99.90	0.00	0.00	124.88	99.90	0.00
Fitz Creek	FITZ-01	1.04	0.178	0.171	A+	Corral-1 (Big Hole)	1.79	9.45	0.37	3.46		10%					90%		0.00	0.35	0.00	0.00	0.00	0.00	3.12	0.00
Fitz Creek	FITZ-02	1.05	0.198	0.189	A+	Corral-1 (Big Hole)	1.79	9.45	0.44	4.18							100%		0.00	0.00	0.00	0.00	0.00	0.00	4.18	0.00
Fitz Creek	FITZ-03	1.08	0.087	0.081	Ba	DRYB-03	1.68	8.87	0.39	3.43		40%					60%		0.00	1.37	0.00	0.00	0.00	0.00	2.06	0.00
Fitz Creek	FITZ-04	1.14	0.127	0.111	E4a	FITZ-04	0.41	2.16	1.01	2.19							100%		0.00	0.00	0.00	0.00	0.00	0.00	2.19	0.00
Fitz Creek	FITZ-05	1.05	0.062	0.059	B	DRYB-03	1.68	8.87	1.34	11.92	10%	30%				30%	30%		1.19	3.58	0.00	0.00	0.00	3.58	3.58	0.00
Fitz Creek	FITZ-06	not classified in AA				FISH-14	14.03	74.08	0.05	3.70	10%	30%					60%		0.37	1.11	0.00	0.00	0.00	0.00	2.22	0.00
Hells Canyon Creek	HELC-01	1.08	0.262	0.243	A+	Corral-1 (Big Hole)	1.79	9.45	1.22	11.54							100%		0.00	0.00	0.00	0.00	0.00	0.00	11.54	0.00
Hells Canyon Creek	HELC-2	1.16	0.095	0.082	B	HELC-03	3.92	20.70	0.64	13.14							100%		0.00	0.00	0.00	0.00	0.00	0.00	13.14	0.00
Hells Canyon Creek	HELC-03	1.05	0.106	0.101	B4a	HELC-03	3.92	20.70	1.24	25.57		96%					4%		0.00	24.55	0.00	0.00	0.00	0.00	1.02	0.00
Hells Canyon Creek	HELC-04	1.13	0.047	0.042	C	HELC-06	1.53	8.08	0.96	7.79	20%	30%					50%		1.56	2.34	0.00	0.00	0.00	0.00	3.90	0.00
Hells Canyon Creek	HELC-05	1.08	0.063	0.058	B	HELC-06	1.53	8.08	0.85	6.86	20%	30%					50%		1.37	2.06	0.00	0.00	0.00	0.00	3.43	0.00
Hells Canyon Creek	HELC-06	1.11	0.048	0.043	B4c	HELC-06	1.53	8.08	0.95	7.66		60%						40%	0.00	4.60	0.00	0.00	0.00	0.00	0.00	3.07
Hells Canyon Creek	HELC-07	1.05	0.056	0.053	B	HELC-06	1.53	8.08	2.16	17.42							100%		0.00	0.00	0.00	0.00	0.00	0.00	17.42	0.00
Hells Canyon Creek	HELC-08	1.11	0.063	0.057	B	HELC-06	1.53	8.08	2.38	19.19						30%	70%		0.00	0.00	0.00	0.00	0.00	5.76	13.43	0.00
Hells Canyon Creek	HELC-09	1.2	0.027	0.023	B	HELC-06	1.53	8.08	0.51	4.11		30%				30%	40%		0.00	1.23	0.00	0.00	0.00	1.23	1.64	0.00
Halfway Creek	HFWY-01		0.011		E	CHRY-06	4.84	25.56	1.00	25.56	10%						90%		2.56	0.00	0.00	0.00	0.00	0.00	23.00	0.00
Halfway Creek	HFWY-02	1.22	0.044	0.036	E	CHRY-06	4.84	25.56	0.29	7.42	10%						90%		0.74	0.00	0.00	0.00	0.00	0.00	6.68	0.00
Halfway Creek	HFWY-03	1.05	0.118	0.112	A+	Corral-1 (Big Hole)	1.79	9.45	0.46	4.37							100%		0.00	0.00	0.00	0.00	0.00	0.00	4.37	0.00
Halfway Creek	HFWY-04	1.13	0.101	0.089	E	CHRY-06	4.84	25.56	0.42	10.80							100%		0.00	0.00	0.00	0.00	0.00	0.00	10.80	0.00
Halfway Creek	HFWY-05	1.17	0.177	0.151	B	HFWY-07	30.46	160.83	1.00	161.41							100%		0.00	0.00	0.00	0.00	0.00	0.00	161.41	0.00
Halfway Creek	HFWY-06	1.31	0.062	0.047	B	HFWY-07	30.46	160.83	2.40	386.05		20%					80%		0.00	77.21	0.00	0.00	0.00	0.00	308.84	0.00
Halfway Creek	HFWY-07	1.35	0.05	0.037	B4c	HFWY-07	9.25	48.84	1.84	89.67		63%					25%	12%	0.00	56.49	0.00	0.00	0.00	0.00	22.42	10.76
Jefferson River	JEFF-01	1.1	0.003	0.003	D4	JEFF-01	140.29	740.73	2.92	2161.87							88%	12%	0.00	0.00	0.00	0.00	0.00	0.00	1902.44	259.42
Jefferson River	JEFF-02	1.09	0.002	0.002	D	JEFF-01	140.29	740.73	2.61	1933.06	15%		25%			30%	30%		289.96	0.00	483.26	0.00	0.00	579.92	579.92	0.00
Jefferson River	JEFF-03	1.05	0.003	0.003	D	JEFF-01	140.29	740.73	2.46	1825.87			40%			40%	20%		0.00	0.00	730.35	0.00	0.00	730.35	365.17	0.00
Jefferson River	JEFF-04	1.23	0.002	0.002	D	JEFF-01	140.29	740.73	2.70	2003.62			30%	20%		30%	20%		0.00	0.00	601.09	400.72	0.00	601.09	400.72	0.00
Jefferson River	JEFF-05	1.36	0.003	0.002	Da	JEFF-01	140.29	740.73	1.91	1414.40									0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Jefferson River	JEFF-06	1.62	0.003	0.002	C4	JEFF-06	122.53	646.96	2.83	1828.64							28%	72%	0.00	0.00	0.00	0.00	0.00	0.00	512.02	1316.62
Jefferson River	JEFF-07	1.55	0.002	0.001	Da	JEFF-01	140.29	740.73	4.58	3395.02									0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Jefferson River	JEFF-08	1.2	0.003	0.003	C	JEFF-06	122.53	646.96	2.67	1728.65									0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Stream	Reach	Sinuosity	Valley Slope	Channel Slope	Rosgen Classification	Most Similar Stream Section used for Modeling Sediment Loading (Monitoring Sections in Bold)	Sediment Load due to Bank Erosion per 1000 Feet (Tons/ Year)	Sediment Load due to Bank Erosion per Mile (Tons/ Year)	Aerial Assessment Reach Length (Miles)	Sediment Load due to Bank Erosion for Entire Aerial Assessment	Sediment Source (Percent)								Sediment Load by Sediment Source (Tons/Year)							
											Transportation	Riparian grazing	Cropland	Mining	Silviculture	Irrigation - shifts in stream energy	Natural sources	Other	Transportation	Riparian grazing	Cropland	Mining	Silviculture	Irrigation - shifts in stream energy	Natural sources	Other
Jefferson River	JEFF-09	1.15	0.002	0.002	Da	JEFF-01	140.29	740.73	3.25	2404.29									0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Jefferson River	JEFF-10	1.31	0.002	0.002	C4	JEFF-10	61.92	326.94	3.68	1203.42							36%	64%	0.00	0.00	0.00	0.00	0.00	0.00	433.23	770.19
Jefferson River	JEFF-11	1.48	0.002	0.001	C	JEFF-10	61.92	326.94	2.98	973.57			33%			33%	34%		0.00	0.00	321.28	0.00	0.00	321.28	331.01	0.00
Jefferson River	JEFF-12	1.46	0.003	0.002	Da	JEFF-01	140.29	740.73	3.03	2243.24			33%			33%	34%		0.00	0.00	740.27	0.00	0.00	740.27	762.70	0.00
Jefferson River	JEFF-13	1.29	0.001	0.001	C	JEFF-10	61.92	326.94	3.76	1228.86	15%	20%	25%			20%	20%		184.33	245.77	307.22	0.00	0.00	245.77	245.77	0.00
Jefferson River	JEFF-14	1.34	0.002	0.001	C	JEFF-10	61.92	326.94	2.12	691.83	15%	20%	25%			20%	20%		103.77	138.37	172.96	0.00	0.00	138.37	138.37	0.00
Little Pipestone Creek	LPST-01	not classified in AA			Ea	LPST-09	61.01	322.13	1.45	467.04		20%				20%	60%		0.00	93.41	0.00	0.00	0.00	93.41	280.22	0.00
Little Pipestone Creek	LPST-02	not classified in AA			B	LPST-06	3.98	21.01	2.13	44.77	20%						80%		8.95	0.00	0.00	0.00	0.00	0.00	35.81	0.00
Little Pipestone Creek	LPST-03	not classified in AA			B	LPST-06	3.98	21.01	1.42	29.83	20%					30%	50%		5.97	0.00	0.00	0.00	0.00	8.95	14.92	0.00
Little Pipestone Creek	LPST-04	1.12	0.04	0.036	E	LPST-09	61.01	322.13	1.08	347.92	20%	20%	20%			20%	20%		69.58	69.58	69.58	0.00	0.00	69.58	69.58	0.00
Little Pipestone Creek	LPST-05	1.04	0.043	0.041	E	LPST-09	61.01	322.13	1.27	409.48	20%	20%	20%			20%	20%		81.90	81.90	81.90	0.00	0.00	81.90	81.90	0.00
Little Pipestone Creek	LPST-06	1.06	0.071	0.067	B4a	LPST-06	3.98	21.01	1.29	27.08							100%		0.00	0.00	0.00	0.00	0.00	0.00	27.08	0.00
Little Pipestone Creek	LPST-07	1.08	0.03	0.028	E	LPST-09	61.01	322.13	1.88	605.62	20%	20%	20%			20%	20%		121.12	121.12	121.12	0.00	0.00	121.12	121.12	0.00
Little Pipestone Creek	LPST-08	1.08	0.011	0.01	E	LPST-09	61.01	322.13	0.86	277.12	20%	30%					50%		55.42	83.14	0.00	0.00	0.00	0.00	138.56	0.00
Little Pipestone Creek	LPST-09	1.32	0.021	0.016	E4	LPST-09	61.01	322.13	2.39	769.83		4%					18%	78%	0.00	30.79	0.00	0.00	0.00	0.00	138.57	600.47
Little Pipestone Creek	LPST-10	1.1	0.008	0.007	F	LPST-09	61.01	322.13	2.40	771.94	10%	30%	30%				30%		77.19	231.58	231.58	0.00	0.00	0.00	231.58	0.00
Whitetail Creek	WHTL-01	1.44	0.004	0.003	C	WHTL-05	16.39	86.54	0.30	26.24							50%	50%	0.00	0.00	0.00	0.00	0.00	0.00	13.12	13.12
Whitetail Creek	WHTL-02	1.05	0.115	0.11	A	Delano-1 (Big Hole)	0.00	0.00	1.69	0.00							100%		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Whitetail Creek	WHTL-03	1.25	0.027	0.022	C	WHTL-05	16.39	86.54	0.31	26.85							100%		0.00	0.00	0.00	0.00	0.00	0.00	26.85	0.00
Whitetail Creek	WHTL-04	1.13	0.09	0.08	B	WHTL-05	16.39	86.54	0.69	59.92							100%		0.00	0.00	0.00	0.00	0.00	0.00	59.92	0.00
Whitetail Creek	WHTL-05	1.32	0.047	0.036	B4c	WHTL-05	16.39	86.54	1.70	146.77		87%				7%	7%		0.00	127.69	0.00	0.00	0.00	10.27	10.27	0.00
Whitetail Creek	wHTL-06	1.23	0.059	0.048	B	WHTL-05	16.39	86.54	1.27	110.11							100%		0.00	0.00	0.00	0.00	0.00	0.00	110.11	0.00
Whitetail Creek	WHTL-07	1.29	0.035	0.027	C	WHTL-05	16.39	86.54	0.35	30.06							100%		0.00	0.00	0.00	0.00	0.00	0.00	30.06	0.00
Whitetail Creek	WHTL-08	1.26	0.037	0.029	B	WHTL-05	16.39	86.54	0.55	47.48							100%		0.00	0.00	0.00	0.00	0.00	0.00	47.48	0.00
Whitetail Creek	WHTL-09	1.13	0.015	0.013	B	WHTL-05	16.39	86.54	0.35	29.96	10%						90%		3.00	0.00	0.00	0.00	0.00	0.00	26.96	0.00
Whitetail Creek	WHTL-10	1.14	0.067	0.059	B	WHTL-05	16.39	86.54	0.37	31.96	10%						90%		3.20	0.00	0.00	0.00	0.00	0.00	28.76	0.00
Whitetail Creek	WHTL-11	1.29	0.024	0.019	C	BPST-12	32.92	173.82	0.70	121.51	10%						90%		12.15	0.00	0.00	0.00	0.00	0.00	109.36	0.00
Whitetail Creek	WHTL-12	1.12	0.036	0.032	B	WHTL-14	8.25	43.56	0.56	24.30							100%		0.00	0.00	0.00	0.00	0.00	0.00	24.30	0.00
Whitetail Creek	WHTL-13	1.16	0.036	0.031	C	BPST-12	32.92	173.82	0.69	120.42	10%	30%					60%		12.04	36.13	0.00	0.00	0.00	0.00	72.25	0.00
Whitetail Creek	WHTL-14	1.22	0.021	0.017	B4c	WHTL-14	8.25	43.56	2.66	115.75		69%				14%	17%		0.00	79.87	0.00	0.00	0.00	16.20	19.68	0.00
Whitetail Creek	WHTL-15	1.81	0.009	0.005	E	LPST-09	61.01	322.13	4.69	1509.20	10%	25%	20%			25%	20%		150.92	377.30	301.84	0.00	0.00	377.30	301.84	0.00
Whitetail Creek	WHTL-16	1.63	0.009	0.006	F4	WHTL-16	27.95	147.58	1.99	292.94		17%				37%	4%	42%	0.00	49.80	0.00	0.00	0.00	108.39	11.72	123.04
Whitetail Creek	WHTL-17	1.82	0.003	0.002	E	LPST-09	61.01	322.13	2.78	896.18	10%	25%	20%			25%	20%		89.62	224.04	179.24	0.00	0.00	224.04	179.24	0.00

APPENDIX H
TOTAL MAXIMUM DAILY LOADS

H.1 Sediment

H.1.1 Overview

A percent reduction approach was used for the sediment TMDLs within this document because there is uncertainty associated with the loads derived from the source assessment, and using the estimated sediment loads creates a rigid perception that the loads are absolutely conclusive. However, because daily loads are a required product of TMDL development and percent reductions are most relevant at an annual scale, loads within this appendix are expressed as daily loads. Daily loads should not be considered absolutely conclusive and may be refined in the future as part of the adaptive management process. The TMDLs may not be feasible at all locations within the watershed, but if the allocations are followed, sediment loads are expected to be reduced to a degree that the sediment targets are met and beneficial uses are no longer impaired.

H.1.2 Approach

The average annual sediment loads determined from source assessments (**Section 5.0**) were used along with historical flow and suspended sediment data from the Big Hole River to determine average daily sediment loads for tributary stream in the Upper Jefferson TPA. This approach was taken primarily due to the lack of flow and sediment data available within Jefferson River. The major assumption of this approach is that the hydrogeologic properties of these watersheds are similar. For this process a sediment rating curve was developed using daily flow and suspended solids load data collected from 1960 through 1964 at the USGS gage on the Big Hole River near Melrose, MT (Station 6025500) (**Figure H-1**). The gage near Melrose was chosen for its period of record (1923-current) and amount of suspended solids data.

The daily mean discharge based on 84 years of record (1923-2007) at the USGS gage was then plugged into the equation for the sediment rating curve to get a daily suspended sediment load. The suspended sediment load is only a fraction of the total load from the source assessment, but provides an approximation of the relationship between sediment and flow in the Big Hole River. Based on the sum of the calculated daily sediment loads, a daily percentage relative to the annual suspended sediment load was calculated for each day. The daily percentages were then applied to the total average annual loads associated with the TMDL percent reductions from **Section 5.0** to determine the average daily load. To conserve resources, this appendix contains daily loads for the Big Pipestone Creek as an example. As discussed in **Section 5.7.1**, the TMDL for Big Pipestone Creek is a 57 percent reduction in the total average annual sediment load, which is roughly equivalent to 2,863 tons/year. The daily percentages discussed above were then multiplied by the annual load of 2,863 tons to get a daily expression of the Big Pipestone Creek TMDL (**Figure H-2, Table H-1**). Although the relationship between sediment and flow is likely different within the 303(d) Listed tributaries in the Upper Jefferson Watershed than in the Big Hole River, it was used to determine average daily loads because it is the best available data and

TMDL implementation activities will not be driven by the daily loads. The daily loads are a composite of the allocations, but as allocations are not feasible on a daily basis, they are not contained within this appendix. If desired, daily allocations may be obtained by applying allocations provided in **Section 5.7.1** to the daily load. Daily loads for all other TMDLs may be derived by using the daily percentages in **Table H-1** and the TMDLs expressed as an average annual load, which are discussed in **Section 5.7** and also provided in **Table H-2**.

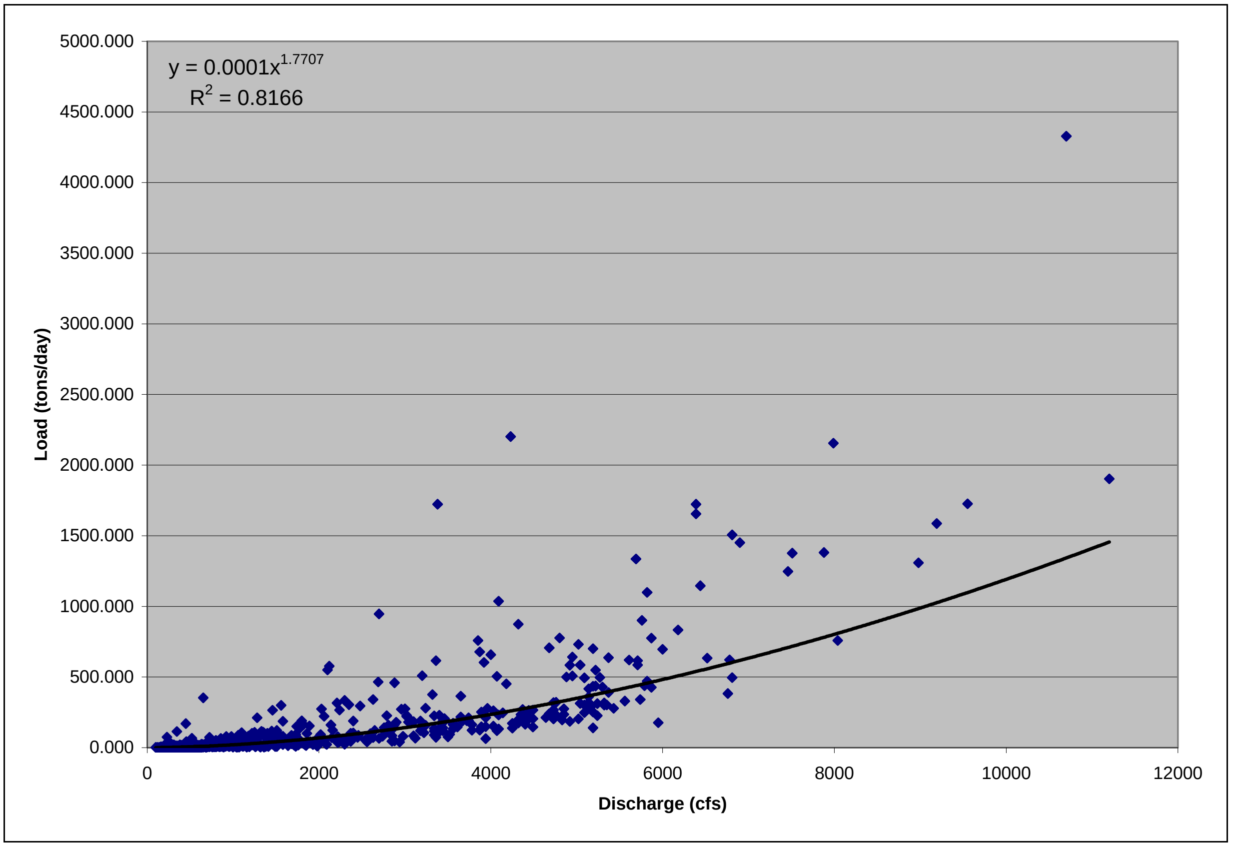

Figure H-1. Sediment Rating Curve for the Big Hole River

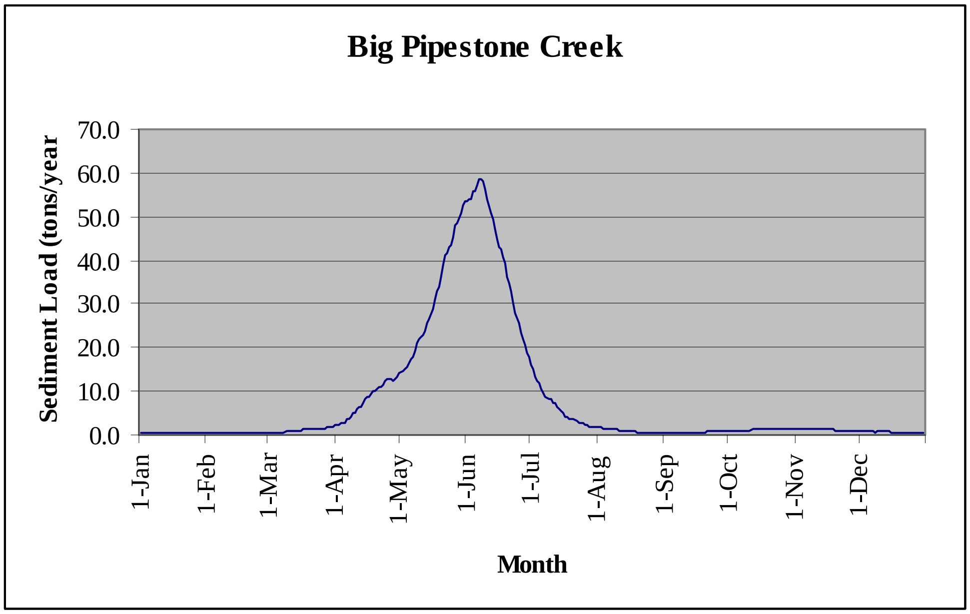

Figure H-2. Average Daily Sediment Load for the Big Pipestone Creek

Table H-1. Daily TMDL for the Big Pipestone Creek.

Month	Day	Daily % of annual load	TMDL (tons/day)	Month	Day	Daily % of annual load	TMDL (tons/day)
Jan	1	0.02%	0.6	Feb	17	0.02%	0.6
Jan	2	0.02%	0.6	Feb	18	0.02%	0.6
Jan	3	0.02%	0.6	Feb	19	0.02%	0.6
Jan	4	0.02%	0.6	Feb	20	0.02%	0.6
Jan	5	0.02%	0.6	Feb	21	0.02%	0.6
Jan	6	0.02%	0.6	Feb	22	0.02%	0.6
Jan	7	0.02%	0.6	Feb	23	0.02%	0.6
Jan	8	0.02%	0.6	Feb	24	0.02%	0.6
Jan	9	0.02%	0.6	Feb	25	0.02%	0.6
Jan	10	0.02%	0.6	Feb	26	0.02%	0.6
Jan	11	0.02%	0.6	Feb	27	0.02%	0.6
Jan	12	0.02%	0.6	Feb	28	0.02%	0.6
Jan	13	0.02%	0.6	Feb	29	0.02%	0.6
Jan	14	0.02%	0.6	Mar	1	0.02%	0.6
Jan	15	0.02%	0.6	Mar	2	0.02%	0.6
Jan	16	0.02%	0.6	Mar	3	0.02%	0.6
Jan	17	0.02%	0.6	Mar	4	0.02%	0.6
Jan	18	0.02%	0.6	Mar	5	0.02%	0.6
Jan	19	0.02%	0.6	Mar	6	0.02%	0.6
Jan	20	0.02%	0.6	Mar	7	0.02%	0.6
Jan	21	0.02%	0.6	Mar	8	0.02%	0.6
Jan	22	0.02%	0.6	Mar	9	0.03%	0.9

Table H-1. Daily TMDL for the Big Pipestone Creek.

Month	Day	Daily % of annual load	TMDL (tons/day)	Month	Day	Daily % of annual load	TMDL (tons/day)
Jan	23	0.02%	0.6	Mar	10	0.03%	0.9
Jan	24	0.02%	0.6	Mar	11	0.03%	0.9
Jan	25	0.02%	0.6	Mar	12	0.03%	0.9
Jan	26	0.02%	0.6	Mar	13	0.03%	0.9
Jan	27	0.02%	0.6	Mar	14	0.03%	0.9
Jan	28	0.02%	0.6	Mar	15	0.03%	0.9
Jan	29	0.02%	0.6	Mar	16	0.03%	0.9
Jan	30	0.02%	0.6	Mar	17	0.04%	1.1
Jan	31	0.02%	0.6	Mar	18	0.04%	1.1
Feb	1	0.02%	0.6	Mar	19	0.04%	1.1
Feb	2	0.02%	0.6	Mar	20	0.04%	1.1
Feb	3	0.02%	0.6	Mar	21	0.04%	1.1
Feb	4	0.02%	0.6	Mar	22	0.04%	1.1
Feb	5	0.02%	0.6	Mar	23	0.04%	1.1
Feb	6	0.02%	0.6	Mar	24	0.04%	1.1
Feb	7	0.02%	0.6	Mar	25	0.05%	1.4
Feb	8	0.02%	0.6	Mar	26	0.05%	1.4
Feb	9	0.02%	0.6	Mar	27	0.05%	1.4
Feb	10	0.02%	0.6	Mar	28	0.06%	1.7
Feb	11	0.02%	0.6	Mar	29	0.07%	2.0
Feb	12	0.02%	0.6	Mar	30	0.07%	2.0
Feb	13	0.02%	0.6	Mar	31	0.07%	2.0
Feb	14	0.02%	0.6	Apr	1	0.08%	2.3
Feb	15	0.02%	0.6	Apr	2	0.08%	2.3
Feb	16	0.02%	0.6	Apr	3	0.08%	2.3
Apr	4	0.09%	2.6	May	21	1.36%	38.9
Apr	5	0.10%	2.9	May	22	1.44%	41.2
Apr	6	0.12%	3.4	May	23	1.46%	41.8
Apr	7	0.13%	3.7	May	24	1.50%	42.9
Apr	8	0.15%	4.3	May	25	1.52%	43.5
Apr	9	0.17%	4.9	May	26	1.58%	45.2
Apr	10	0.18%	5.2	May	27	1.67%	47.8
Apr	11	0.20%	5.7	May	28	1.70%	48.7
Apr	12	0.22%	6.3	May	29	1.78%	51.0
Apr	13	0.23%	6.6	May	30	1.84%	52.7
Apr	14	0.25%	7.2	May	31	1.87%	53.5
Apr	15	0.28%	8.0	Jun	1	1.87%	53.5
Apr	16	0.30%	8.6	Jun	2	1.88%	53.8
Apr	17	0.31%	8.9	Jun	3	1.88%	53.8
Apr	18	0.35%	10.0	Jun	4	1.95%	55.8
Apr	19	0.35%	10.0	Jun	5	1.95%	55.8

Table H-1. Daily TMDL for the Big Pipestone Creek.

Month	Day	Daily % of annual load	TMDL (tons/day)	Month	Day	Daily % of annual load	TMDL (tons/day)
Apr	20	0.36%	10.3	Jun	6	2.00%	57.3
Apr	21	0.38%	10.9	Jun	7	2.04%	58.4
Apr	22	0.38%	10.9	Jun	8	2.04%	58.4
Apr	23	0.40%	11.5	Jun	9	2.03%	58.1
Apr	24	0.43%	12.3	Jun	10	1.96%	56.1
Apr	25	0.45%	12.9	Jun	11	1.89%	54.1
Apr	26	0.45%	12.9	Jun	12	1.78%	51.0
Apr	27	0.44%	12.6	Jun	13	1.73%	49.5
Apr	28	0.43%	12.3	Jun	14	1.65%	47.2
Apr	29	0.45%	12.9	Jun	15	1.56%	44.7
Apr	30	0.47%	13.5	Jun	16	1.50%	42.9
May	1	0.50%	14.3	Jun	17	1.48%	42.4
May	2	0.51%	14.6	Jun	18	1.43%	40.9
May	3	0.52%	14.9	Jun	19	1.37%	39.2
May	4	0.55%	15.7	Jun	20	1.27%	36.4
May	5	0.58%	16.6	Jun	21	1.21%	34.6
May	6	0.60%	17.2	Jun	22	1.15%	32.9
May	7	0.62%	17.8	Jun	23	1.06%	30.3
May	8	0.67%	19.2	Jun	24	0.97%	27.8
May	9	0.73%	20.9	Jun	25	0.89%	25.5
May	10	0.76%	21.8	Jun	26	0.82%	23.5
May	11	0.79%	22.6	Jun	27	0.77%	22.0
May	12	0.80%	22.9	Jun	28	0.72%	20.6
May	13	0.83%	23.8	Jun	29	0.66%	18.9
May	14	0.89%	25.5	Jun	30	0.62%	17.8
May	15	0.93%	26.6	Jul	1	0.56%	16.0
May	16	1.01%	28.9	Jul	2	0.52%	14.9
May	17	1.08%	30.9	Jul	3	0.47%	13.5
May	18	1.15%	32.9	Jul	4	0.43%	12.3
May	19	1.18%	33.8	Jul	5	0.41%	11.7
May	20	1.26%	36.1	Jul	6	0.37%	10.6
Jul	7	0.33%	9.4	Aug	22	0.02%	0.6
Jul	8	0.31%	8.9	Aug	23	0.02%	0.6
Jul	9	0.29%	8.3	Aug	24	0.02%	0.6
Jul	10	0.28%	8.0	Aug	25	0.02%	0.6
Jul	11	0.26%	7.4	Aug	26	0.02%	0.6
Jul	12	0.25%	7.2	Aug	27	0.02%	0.6
Jul	13	0.23%	6.6	Aug	28	0.02%	0.6
Jul	14	0.21%	6.0	Aug	29	0.02%	0.6
Jul	15	0.19%	5.4	Aug	30	0.02%	0.6
Jul	16	0.17%	4.9	Aug	31	0.02%	0.6

Table H-1. Daily TMDL for the Big Pipestone Creek.

Month	Day	Daily % of annual load	TMDL (tons/day)	Month	Day	Daily % of annual load	TMDL (tons/day)
Jul	17	0.15%	4.3	Sep	1	0.02%	0.6
Jul	18	0.14%	4.0	Sep	2	0.02%	0.6
Jul	19	0.13%	3.7	Sep	3	0.02%	0.6
Jul	20	0.13%	3.7	Sep	4	0.02%	0.6
Jul	21	0.12%	3.4	Sep	5	0.02%	0.6
Jul	22	0.11%	3.1	Sep	6	0.02%	0.6
Jul	23	0.10%	2.9	Sep	7	0.02%	0.6
Jul	24	0.10%	2.9	Sep	8	0.02%	0.6
Jul	25	0.09%	2.6	Sep	9	0.02%	0.6
Jul	26	0.08%	2.3	Sep	10	0.02%	0.6
Jul	27	0.08%	2.3	Sep	11	0.02%	0.6
Jul	28	0.07%	2.0	Sep	12	0.02%	0.6
Jul	29	0.07%	2.0	Sep	13	0.02%	0.6
Jul	30	0.07%	2.0	Sep	14	0.02%	0.6
Jul	31	0.07%	2.0	Sep	15	0.02%	0.6
Aug	1	0.06%	1.7	Sep	16	0.02%	0.6
Aug	2	0.06%	1.7	Sep	17	0.02%	0.6
Aug	3	0.06%	1.7	Sep	18	0.02%	0.6
Aug	4	0.05%	1.4	Sep	19	0.02%	0.6
Aug	5	0.05%	1.4	Sep	20	0.02%	0.6
Aug	6	0.05%	1.4	Sep	21	0.03%	0.9
Aug	7	0.04%	1.1	Sep	22	0.03%	0.9
Aug	8	0.04%	1.1	Sep	23	0.03%	0.9
Aug	9	0.04%	1.1	Sep	24	0.03%	0.9
Aug	10	0.04%	1.1	Sep	25	0.03%	0.9
Aug	11	0.03%	0.9	Sep	26	0.03%	0.9
Aug	12	0.03%	0.9	Sep	27	0.03%	0.9
Aug	13	0.03%	0.9	Sep	28	0.03%	0.9
Aug	14	0.03%	0.9	Sep	29	0.03%	0.9
Aug	15	0.03%	0.9	Sep	30	0.03%	0.9
Aug	16	0.03%	0.9	Oct	1	0.03%	0.9
Aug	17	0.03%	0.9	Oct	2	0.03%	0.9
Aug	18	0.03%	0.9	Oct	3	0.03%	0.9
Aug	19	0.02%	0.6	Oct	4	0.03%	0.9
Aug	20	0.02%	0.6	Oct	5	0.03%	0.9
Aug	21	0.02%	0.6	Oct	6	0.03%	0.9
Oct	7	0.03%	0.9	Nov	22	0.03%	0.9
Oct	8	0.03%	0.9	Nov	23	0.03%	0.9
Oct	9	0.03%	0.9	Nov	24	0.03%	0.9
Oct	10	0.03%	0.9	Nov	25	0.03%	0.9
Oct	11	0.03%	0.9	Nov	26	0.03%	0.9

Table H-1. Daily TMDL for the Big Pipestone Creek.

Month	Day	Daily % of annual load	TMDL (tons/day)	Month	Day	Daily % of annual load	TMDL (tons/day)
Oct	12	0.04%	1.1	Nov	27	0.03%	0.9
Oct	13	0.04%	1.1	Nov	28	0.03%	0.9
Oct	14	0.04%	1.1	Nov	29	0.03%	0.9
Oct	15	0.04%	1.1	Nov	30	0.03%	0.9
Oct	16	0.04%	1.1	Dec	1	0.03%	0.9
Oct	17	0.04%	1.1	Dec	2	0.03%	0.9
Oct	18	0.04%	1.1	Dec	3	0.03%	0.9
Oct	19	0.04%	1.1	Dec	4	0.03%	0.9
Oct	20	0.04%	1.1	Dec	5	0.03%	0.9
Oct	21	0.04%	1.1	Dec	6	0.03%	0.9
Oct	22	0.04%	1.1	Dec	7	0.03%	0.9
Oct	23	0.04%	1.1	Dec	8	0.02%	0.6
Oct	24	0.04%	1.1	Dec	9	0.03%	0.9
Oct	25	0.04%	1.1	Dec	10	0.03%	0.9
Oct	26	0.04%	1.1	Dec	11	0.03%	0.9
Oct	27	0.04%	1.1	Dec	12	0.03%	0.9
Oct	28	0.04%	1.1	Dec	13	0.03%	0.9
Oct	29	0.04%	1.1	Dec	14	0.03%	0.9
Oct	30	0.04%	1.1	Dec	15	0.03%	0.9
Oct	31	0.04%	1.1	Dec	16	0.02%	0.6
Nov	1	0.04%	1.1	Dec	17	0.02%	0.6
Nov	2	0.04%	1.1	Dec	18	0.02%	0.6
Nov	3	0.04%	1.1	Dec	19	0.02%	0.6
Nov	4	0.04%	1.1	Dec	20	0.02%	0.6
Nov	5	0.04%	1.1	Dec	21	0.02%	0.6
Nov	6	0.04%	1.1	Dec	22	0.02%	0.6
Nov	7	0.04%	1.1	Dec	23	0.02%	0.6
Nov	8	0.04%	1.1	Dec	24	0.02%	0.6
Nov	9	0.04%	1.1	Dec	25	0.02%	0.6
Nov	10	0.04%	1.1	Dec	26	0.02%	0.6
Nov	11	0.04%	1.1	Dec	27	0.02%	0.6
Nov	12	0.04%	1.1	Dec	28	0.02%	0.6
Nov	13	0.04%	1.1	Dec	29	0.02%	0.6
Nov	14	0.04%	1.1	Dec	30	0.02%	0.6
Nov	15	0.04%	1.1	Dec	31	0.02%	0.6
Nov	16	0.04%	1.1				
Nov	17	0.04%	1.1				
Nov	18	0.04%	1.1				
Nov	19	0.04%	1.1				
Nov	20	0.03%	0.9				
Nov	21	0.03%	0.9				

Table H-2. Upper Jefferson Tributary TMDLs

Stream Segment	**Water Body #**	**TMDL expressed as average annual load (tons/year)**
Big Pipestone Creek, from headwaters to mouth (Jefferson River)	MT41D001_020	2,863
Cherry Creek, from headwaters to mouth (Jefferson River)	MT41D002_090	357
Fish Creek, from headwaters to mouth (Jefferson River)	MT41D003_070	2,077
Hells Canyon Creek, from headwaters to mouth (Jefferson River)	MT41D003_030	974
Little Pipestone Creek, from headwaters to mouth (Big Pipestone Creek)	MT41D003_220	3,461
Whitetail Creek, from headwaters to mouth (Jefferson River)	MT41D003_050	5,293